DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

FOR THE YEAR 1943 VOLUME IV

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The Progress of Science

A MONTHLY NOTEBOOK COMPILED UNDER THE DIRECTION OF DAVID S. EVANS

Blue Print of Policy

THE flames of war now envelope every continent of the world. Luxuries and material comforts have gone for the duration: culture and education fight a hard battle against the destruction of material, buildings and equipment; against paper rationing and staff shortages; against calling-up and evacuation.

But the war itself has brought a new realization of the importance of the proper use of technical resources in the life of the community. There is a growing realization among the public at large that, in the last analysis, the technical resources of victory are the product of the laboratories of the United Nations. Thus it has been the case that almost all of the controversial issues of public discussion, and many important news items which have appeared since the war began, have had a technical basis. The problems of A.R.P., the counter to the magnetic mine, radiolocation, nutritional problems, the development of mass-radiography, and many more, are all instances of the part which science is playing in our war-time life.

Thus it is that it has been decided to republish DISCOVERY, which until March 1940, when it fell a victim to war-time difficulties, was published by the Cambridge University Press. It is dressed in a "utility" suit that enables a great deal of matter to be compressed into a small body.

The war has created a situation in which a journal of science with a popular appeal will have a very important part to play in attempting to bring to the notice of the public the fundamental importance of scientific advances for the mere continuance of our civilization.

But we must look still farther ahead. The war has brought very fundamental changes in the organization of science, and in the methods of training scientific personnel. It has broadened the outlook not only of the general public but of scientists themselves by demonstrating that the possible fields of application of the methods of scientific investigation extend far beyond the limits of what was formerly included in the term "science". Many of these new developments are likely to be of a permanent character and may play an important part in the development of the post-war world.

The word "reconstruction" is, often prematurely, on everyone's lips to-day. What is to be the character of that reconstruction? The scientist of to-day realizes clearly that it will be only an empty form if the resources of science are not employed in the construction of the new world with the same thoroughness and determination with which they are now being applied to war. If that object is to be achieved it will only be at the demand of an enlightened public opinion, with an appreciation of the potentialities of science, a capacity for distinguishing the genuine from the fake, and, to some extent, an ability to think scientifically about technical matters.

From these considerations the policy of DISCOVERY springs. It will attempt not only to describe the work of the scientist, and to bridge the undoubted gap which at present exists between the men in the laboratory and the man in the street, but it will attempt to set these new advances in their true place against the background of modern science. As far as present circumstances permit it will give a record of science news, and try to provide an informed commentary on general news of scientific and technical importance. It undertakes this task in the belief that a public opinion appreciative of the benefits of science and capable of independent criticism on such topics will be an asset not only in the rebuilding of the world after the war, but here and now amid that war's urgent and imperative tasks.

Scientific News

THESE notes will be concerned mainly with the latest developments of science and to that extent merit the title of science news. However, such news differs very much in presentation and content from ordinary news. The most recent advances of science are received with a certain amount of reservation in scientific circles, for it is the essence of the scientific method that all progress is checked and re-checked before being incorporated as a part of the

general edifice of scientific knowledge. The ordinary reader obtains from his newspaper information which is almost certain to be true and which to some extent is of greater merit the more startling its content. It deals with very recent happenings and is out of date within a few hours.

The scientist however reads the journals which are the newspapers of science with very different objects. He is in search of an information of a permanent character, and although he knows that few scientific papers are published except as the sequel to many weeks or years of experiment and close discussion, nevertheless he almost always accepts their conclusions, and especially the more startling conclusions, with a greater or less degree of reservation. Often he will disagree with the interpretation of experimental results described by his colleagues. Sometimes he will even discount a whole series of experiments because he feels that the technique employed is not above criticism.

This difference in attitude raises problems in the presentation of recent advances of science to a general audience. From time to time we shall remind our readers that results published during the last few weeks have not yet passed the test of criticism by other scientists. To some extent our readers must accept these notes as provisional, as pointers to the general direction of scientific advance, rather than as statements of established scientific fact on which all scientists would agree.

Feeding the German Army

THE war has already provided several instances of the importance of studying the weapons and techniques of the enemy. The Germans learned the importance of parachute troops from the Russians. The field of army feeding is one which we may in return gain help from the practice of our enemy.

There is no doubt that the German High Command has been food-conscious during the past seven years. They have clearly recognized that physical efficiency is not to be attained by marching and rigorous exercise alone, and as early as 1934 they were giving serious consideration to the physical well-being and dietary of their troops. Dr. Gerson, writing in the *New York Journal of State Medicine*, quoted the published results of the investigations of the German Services surgeons on the nutritional state of the serving men. They found that all three services showed a marked deficiency of vitamin C, whilst in the army, the prevalence of cases of constipation and nervous heart indicated a deficiency of vitamin B_1 also.

The German authorities set out systematically to correct these and other deficiencies. First, they decided on the number of calories, that is the amount of energy, which the soldier would need if he was to do his work efficiently, The result was given as 3,800 per day when not fighting. and 4,100 when the soldier was actually in battle. As the reader probably consumes about 3,000 calories per day, he will see that the German service man was not hungry.

Calories are derived from three distinct types of food—proteins, fats, and carbohydrates. The best relative proportions of each of these foods were then determined with the object of supplying not only sufficient calories, but adequate amounts of the essential vitamins and minerals as well. A man may have a diet containing an adequate supply of energy and yet become ill because his food does not contain sufficient vitamins. It may be stale or badly cooked so that its vitamin content has been lowered.

The men of the German forces are encouraged to eat large quantities of a coarse-ground, whole rye bread, called *Komissbrot* (about $1\frac{2}{3}$lb. per day), which gives about 1,820 calories, and also ensures a good supply of the vitamins of the B group. Two pounds of potatoes are provided daily for each man, giving not only a large supply of calories but forming a source of vitamin C. The water in which they are cooked, which may contain 50% of the vitamins of the potatoes, is used in making soups and sauces.

A special preparation of sugar, powdered milk, vitamins of vegetable origin, and fruit essence is carried by most troops. Soldiers in forts and below the surface get foods especially rich in vitamin D, to make up for the supply of this vitamin which normally comes from the action of sunlight on the skin. Such foods are smoked fish, butter, eggs, cheese, milk, and yeast. The latter presumably refers to irradiated yeast, because normally yeast contains only a negligible amount of vitamin D.

Submarine crews are given foods rich in vitamin D, and also foods such as vegetable and potato powder, and milk powder, which take up only a small space. Troops in the tropics are, as far as possible, given fresh fruits frozen at low temperatures—a process which preserves the vitamins—and milk powders. Men in the Arctic receive meat and vegetable powders and dried pressed fruits. Owing to the outbreaks of mild scurvy and tooth troubles last winter in the army of occupation in Norway, they now receive vitamin C tablets.

It is probable that owing to the exigencies of battle these principles have been modified, but they represent, nevertheless, a considerable improvement on older methods of army feeding.

The Behaviour of Matter at very Low Temperatures

THE study of the properties of matter at very low temperatures in the neighbourhood of absolute zero has, surprisingly enough, led to the explanation of important properties of matter at quite ordinary temperatures, and to the elucidation of certain fundamental features of the microscopic structure of matter. Advances in this field of knowledge are therefore of much more than academic interest, and a comparison of two important, and hitherto unexplained, phenomena, which only occur at these very low temperatures may be of great importance for the development of physics.

These two phenomena are superconductivity, or the complete loss of electrical resistance by certain metals at temperatures near absolute zero, and the anomalous behaviour of liquid helium at similar degrees of cold.

Superconductivity is a very striking phenomenon, for the complete loss of resistance means that a current once started in a ring of superconducting metal never dies away, as currents do in ordinary metals when the battery which started the current is removed. If the temperature of such

a ring is allowed to rise above a particular value characteristic of the metal concerned, it ceases to be superconducting and behaves quite normally.

There is a similar critical temperature in the case of liquid helium. Below this temperature the liquid exhibits an extremely high heat conductivity which is much better than even the best metal, and a viscosity which is practically zero. In 1938 Dr. J. G. Daunt and Dr. K. Mendelssohn, working at the Clarendon Laboratory at Oxford, observed a very striking phenomenon. They found that below the critical temperature a thin film of helium atoms was formed on the walls of the vessel, and that this film climbed steadily upwards in defiance of gravity, until it flowed over the lip of the vessel and accumulated at the lowest available level. This behaviour is as striking as if tea could not be confined in a cup because it persistently climbed out over the edge of its own accord. This film was found to be only about a hundred atoms in thickness, and further investigation suggested that it extended over the whole of the surface of the vessel, continuing even below the liquid level. Daunt and Mendelssohn attributed the high heat conductivity and the small viscosity of the liquid to the action of this film.

Recently the same two authors have pointed out that very striking analogies exist between the behaviour of superconducting metals and of liquid helium. In the former case it is impossible to maintain a difference of electrical potential between different parts of the metal: in the helium film it is impossible to maintain a temperature difference between the ends. In the one case there is a frictionless transport of electrons, i.e., an electric current, and in the other a frictionless transport of helium atoms. Both phenomena only begin to manifest themselves when the temperatures are below certain critical values, which are different for the various cases, and the phenomena do not appear at all above these temperatures. In both cases the rate of flow depends only on the width of the connecting surface and not on its length; there is a definite limit to the rate of flow at each temperature, and this limit is increased as the temperature is lowered.

Daunt and Mendelssohn suggest as an explanation of these effects, that even before absolute zero is reached, some of the atoms or electrons pass into a peculiar, "unexcited" state, in which they no longer have any interaction with their neighbours. This enables them to pass freely through the material, exempt from the ordinary interatomic forces which rapidly check such motion in ordinary matter. However, they are under the influence of external forces, such as, in the case of helium, the influence of the vessel wall, and the phenomena are therefore confined to a very thin surface layer which represents the depth to which these external forces can penetrate into the body of the material.

The observed specific heat of helium and of superconductors is high, a fact which receives an explanation on this basis, for it means that energy is needed to bring the atoms out of their "unexcited" state when the temperature begins to rise. On the other hand there is evidence that the atoms and electrons do not take up heat as long as they remain in the "unexcited" state.

The hypothesis also accounts for the other phenomena observed, in particular the increase in the limiting flow as the temperature is lowered, for this corresponds to the fact that as the temperature is lowered, more and more atoms or electrons pass into the "unexcited" state, and become available to take part in the frictionless flow.

The suggestion that a certain amount of energy is needed to bring the particles from the "unexcited" into the normal state makes the transition somewhat similar to the familiar cases of boiling and melting, in which a similar expenditure of energy is necessary to bring the particles into a new state. The transition from a solid to a liquid takes up a great deal of energy, the transition from "unexcited" to normal atoms equally requires a great deal of energy, and the authors conclude by suggesting that this transition is a change of state, somewhat analogous to these familiar changes, and one which can be discussed with equal generality. Many things can be said about boiling and melting without reference to the particular kind of substance concerned. In just the same way it appears to be immaterial whether the transition from "unexcited" particles is concerned with electrons or with helium atoms.

Chemical Triggers

IN recent years it has become increasingly clear that certain specific substances present in living matter in minute concentrations may play an important part in the growth, behaviour, and general functions of the organism. The subject matter of these researches is excessively complicated, and the scientist often yearns for a simplification of the experimental conditions which will enable him to see his way through a situation in which a myriad factors play a part in the final result.

It is for this reason that the recent work on the biochemistry of a tiny unicellular plant called Chlamydomonas is of importance. Here the investigator could get to grips with his material, and view a wood unobscured by a multitude of trees.

This microscopic organism is definitely not an animal in spite of the fact that it can swim about in water by the aid of two tiny whip-like organs called flagella situated at its front end, for it contains the pigment chlorophyll and synthesizes its food from carbon dioxide and water just as plants do.

In a series of brilliant experiments it was found that Chlamydomonas could be grown in the dark on agar (a kind of jelly used in growing bacteriological cultures), and that under these conditions they were devoid of flagella, and could not move about even when suspended in water. However, when a suspension of these cells in water was irradiated with a strong light, the flagella began to grow after about three minutes, the process being completed after a further two minutes. It was subsequently found that this change is due to the synthesis in the presence of light of a chemical substance called Crocin. This is an extremely potent substance, for the same change can be brought about even in the dark by the addition of Crocin in a concentration as low as 1 part in 250,000,000,000,000. This means that each cell may grow its flagella and become motile under the influence of only 1 molecule of Crocin.

The Crocin is synthesized by the action of light from a complex series of pigments called Carotenoids which are normally present in the plant, and which are widely distributed in nature, being responsible among other things for

the colour of carrots and tomatoes. However, in addition to Crocin, certain other substances are synthesized in Chlamydomonas which are essential for the normal life of the organism.

There are male and female forms of one species of Chlamydomonas which come together in pairs and fuse, subsequently dividing into two, four or eight new individuals. It is possible to prepare agar cultures of each sex separately in the dark, and as long as they remain so, they lack not only flagella for movement, but reproductive ability as well. After about 20 to 30 minutes' irradiation the female cells become ready to conjugate, but the male cells require a total time of 1 hour.

The chemical substance behind this process was found to be Crocetin Dimethyl Ester, which exists in two forms, chemically identical and differing only in the orientation of the molecules in space. The first is called the cis-ester and the second the trans-ester. Under irradiation the former is formed first and is then gradually transformed into the latter. The striking point is that the female cells are ready for conjugation when the ratio between these two substances is 3 to 1, but the male cells only become ready when so much of the latter has been formed that the ratio is 1 to 3.

Finally, it has been found that the sex of this peculiar organism is actually controlled by carotenoid derivatives. This was demonstrated in the following ingenious way. An hermaphrodite strain of the organism was prepared, that is, a strain which was capable of behaving as male in the presence of females, and as female in the presence of males. It was found that the introduction of a carotenoid derivative called Saffronal caused all the hermaphrodite cells to become males, while another derivative called Picrocrocin turned them all into females.

This work shows the extraordinary power of a particular class of very complex chemical substances in determining the whole life history of a particular organism, and is certain to stimulate other workers to investigate the behaviour of other, and perhaps more complex, types of organisms.

The Treatment of Tuberculosis

TUBERCULOSIS of the lungs is one of the most important problems facing medical science to-day. It is a common disease, with a world-wide incidence, which affects principally young adults between the ages of 15 and 35. It presents a social problem of the greatest importance, for even before the war it killed about 30,000 people annually in England and Wales, and caused an incalculable amount of ill-health and disablement. It is very much a "social" disease, for its incidence is directly related to real wages. In war-time its incidence rises, and in 1918 the mortality among females aged from 15 to 24 years rose 35% as compared with the 1914 figure. In this war too there has been a marked rise in its incidence.

Existing treatments are often distressingly unsatisfactory and take two forms. Sanatorium treatment consists essentially in raising the standard of living of the patient under controlled conditions, but all too often fails because the patient returns after treatment to the environment which played so large a part in the original development of his disease.

Surgical treatment has the purely mechanical aim of collapsing and thus resting the affected lung, but the number of cases in which such treatment is possible is limited.

Neither of these lines of treatment attacks the central problem, which is the failure of the patient's own powers of resistance to overcome the disease. It is known that infection with the tuberculosis bacillus affects between 50% and 70% of people in the most susceptible age groups, and yet only a small percentage of these people actually develop the disease, because the majority have sufficient powers of resistance to overcome it.

The claims of Dr. C. Robertson Lavalle of Buenos Aires are therefore of great interest in this connexion. He claims that he has been able to assist those whose natural resistance has been overcome simply by puncturing the patient's lung in a particular place on a single occasion.

The basis for this startlingly simple procedure is as follows. He claims that, on the basis of stereoscopic X-ray examination, he is able to locate a focus of infection at a particular point on the lung, which shows up as a small shadow about an inch in diameter. He asserts that this represents a scarring lesion in which are localized the substances which normally circulate freely in the body and which are responsible for its resistance. His object is to puncture this and to release these substances, with a consequent improvement in the patient's general condition and in the healing powers of the affected lung tissue.

His first paper, published in 1937, was based on only 200 cases of lung puncture and was viewed with mistrust by chest specialists in this country, but it dealt with a greater number of cases of bone and joint tuberculosis treated by essentially the same method. The method has been adopted by at least one orthopædic surgeon in this country and he is pleased with his results. The second paper, published in 1942, reports 1000 cases, some of which have been followed up for ten years. Unfortunately, no details are given of the criteria by which Lavalle estimated his results. He claims a successful result in 60% to 70% of cases of early tuberculosis, and 40% to 50% in late cases. If by "successful" he means a cure, this is a notable advance.

In this connexion the remarks of another British specialist are worthy of note. He had been using a method of drainage of lung cavities for the treatment of advanced cases, and noted that in two cases, when lung punctures had actually failed to locate the cavity and the planned object of the treatment had therefore not been achieved, that nevertheless the patient showed a striking improvement afterwards. He himself suggests that the puncture may have traumatized Lavalle's area accidentally and have owed its success to this fact.

Lavalle's treatment is far from established and medical men will almost certainly accept his claims with reserve, but it is easy to carry out and quite safe, for lung puncture is a frequent accidental occurrence in the operation for collapsing the lung, and no ill-effects are observed. The results of further investigation should be of great interest.

Non-Reflecting Glass

WHEN light passes through the boundary between two media having different refractive indices, not all of the incident light passes through, some of it being reflected

back instead. This is very obvious when one tries to look through the window of a lighted room or vehicle after dark, the interior illumination being so much brighter than that outside that the small fraction of it which is reflected (about 5% at each surface of the glass) is sufficient to overcome completely the feeble light from the scene outside; but surface reflection from glass is also a nuisance in picture frames, shop windows, switch-board meters, cathode-ray tubes, and optical instruments, and so deserves to be treated as a serious problem.

For some years it has been realized that this reflection could be greatly reduced by making the transition between air and glass in two stages such that the two reflections then produced cancel out each other, leaving no resultant reflection. Light is of course transmitted by electromagnetic waves, and on reaching the boundary between air and glass the incident wave I is divided between a transmitted part T and a reflected part R as shown in Fig. 1. (The reflected wave is drawn displaced from its actual position for the sake of clarity.) The effect of adding to the surface of the glass a film of thickness equal to a quarter of a wavelength of the light is shown in Fig. 2; the second reflection R_2 starts a quarter wave later than R_1 (because the incident light must first travel through the film) and also has a quarter wavelength to travel before it joins up with R_1, so that altogether there is a difference of a half wavelength between R_1 and R_2. But this means that the waves of R_1 and R_2 are exactly in opposition, so that if the refractive index of the film is chosen to make them equal in magnitude, they will cancel out and there will be no reflection. A feature which is not so obvious from this qualitative description of the mechanism is that when there is no reflection from the com-

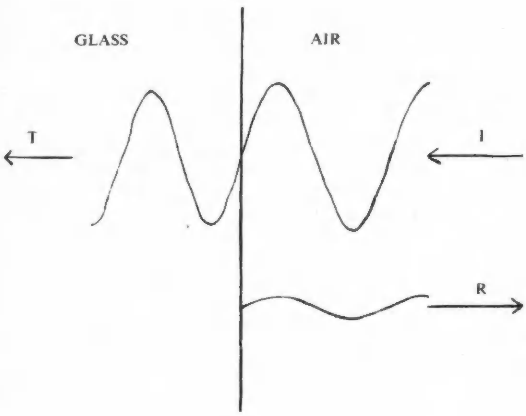


FIG. 1.

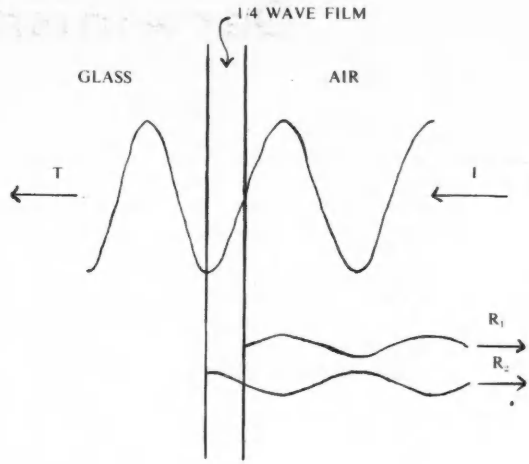


FIG. 2.

posite surface the corresponding loss of light from the transmitted ray is eliminated, so that, apart from a very small loss due to true absorption in the glass, all the light is transmitted.

The theory is simple, but it has taken much effort to overcome the two practical difficulties; the film thickness must be accurately controllable, and the film must be made of a substance which both has the right reflexive index and will stand up to atmospheric conditions and reasonable use. Preferably it should also be easy to make, and possible to apply to large surfaces. Since the wavelength varies with the colour of light, the film cannot be exactly correct for the whole spectrum; it is usually made right for the middle of the spectrum (yellow and green), giving some reflection of red and blue which together give the surface a purple tint. Many methods of making the film have been tried, some of them limited to particular types of glass, many of them producing a film which will not stand weather or handling, and others (deposition of the film by vacuum evaporation) too expensive to apply to large surfaces. A useful new method reported by R.C.A. (of America) is to employ a glass containing lime and expose it to the vapour of dilute hydrofluoric acid, producing a film of calcium fluoride; this is a simple and cheap process, and the film formed is satisfactorily stable. A "fluoride-coated" photographic lens of wide aperture (*f.* 0.8) has already been mentioned in this country in connexion with miniature photography of X-ray fluorescent screens, for which maximum light transmission is required owing to the low illumination of the fluorescent screen.

Darwinism To-day

JULIAN S. HUXLEY D.Sc., F.R.S.

DARWIN'S great book, *The Origin of Species*, comprised two quite distinct elements. In the first place, it demonstrated, with a vast wealth of examples, that the current theory of the fixity of species was untenable, whether in its theological guise of special creation or in any other form; it simply would not fit the facts of nature. The facts of nature demanded an evolutionary theory: gradual change was the rule in life, constantly producing new types—not only new species, but also larger groups of every degree. In the second place, Darwin proposed a mechanism to account for evolution—the theory of Natural Selection, by which favourable varieties would automatically be accumulated and the apparent purposefulness of life could be accounted for in straightforward mechanistic terms.

It was this latter element which gave Darwin's work its influence among professional biologists. Many of them were ripe for conversion to the idea of evolution, but before 1859 no one had put forward any but the most improbable suggestions as to how evolution could have been brought about. T. H. Huxley, for instance, records how, when he read the *Origin*, he said to himself, "How stupid of me not to have thought of that!" and from then on became the champion of Darwinism.

This Darwinian view of evolution was generally accepted by biologists in the latter part of last century. But about 1890 doubts began to be thrown upon it, and around 1910 it had become so unfashionable that some critics proclaimed the death of Darwinism. By this, of course, was meant the selectionist theory of the method of evolution: the fact that evolution has occurred was never seriously questioned after 1859.

This sceptical attitude was due to two main causes. For one thing, orthodox Darwinism was tending to become purely speculative, invoking natural selection to explain anything and everything without requiring proof and without providing any explanation of the machinery by which the results could be brought about. For another, genetics had discovered the fact of mutation—in other words, that hereditary change proceeds by jumps; and the theory was advanced that evolution proceeded by large jumps, not by the gradual change which was the keystone of Darwin's view.

In the last 25 years, however, an enormous amount of new facts about evolution and heredity have been discovered, and the balance has now swung over heavily, and, I think, permanently, in favour of Darwinism. Chief among these new facts is the discovery that most mutations are not large, but very small steps of change.

It turns out that the reports of the death of Darwinism, like those of the death of Mark Twain, were very much exaggerated. Indeed, the net result of the last quarter century's work in biology has been the re-establishment of natural selection as the essential method of evolution and its re-establishment not merely where Darwin left it, but on a far more secure footing. For one thing, the alternative explanations have ceased to be plausible. First among these is Lamarckism, or the so-called inheritance of acquired characters (which means the inheritance of characters acquired by an individual as a result of changes in the environment, like tanning due to sun, or of use or disuse of organs, like the more powerful muscles of the athlete or heavy worker; it does not refer to characters "acquired" through new mutation). This has now been thoroughly discredited. It has been definitely disproved in a number of cases; it cannot in any case apply to a large range of facts (such as the evolution of the hard skeleton of higher insects, or of our own teeth); the apparent examples of its existence have all been shown either to be due to error, or susceptible of an alternative explanation; and it is logically self-contradictory.

Second, there is orthogenesis, or evolution in a predetermined direction, supposedly due to the germ-plasm being predestined to vary only in a certain way. It is true that when we can trace the actual course of evolution by means of abundant fossils, we often find that it does proceed in straight lines. The most familiar example is the steady evolution of the horse towards speed and the one-toed foot and towards elaborate teeth for grinding grass—but wherever (as is in most cases obvious) the direction is towards greater efficiency, this is to be expected on the basis of natural selection (Figs. 1 and 2). In any case, there are some examples, like that of the elephants or the baboons, where evolution is not in a straight line, but changes direction during its course. There are a few puzzling cases, like the trend towards apparently useless or harmful characters, as seen in a number of groups of Ammonites shortly before their final extinction; but they are quite exceptional, and may prove to be susceptible of alternative explanation. In any case, orthogenesis in a useless (or harmful) direction, would demand mutation-rates much higher than any yet found in nature.

There are also the vitalistic theories of a mysterious life-force or unconscious purpose, like Bergson's *élan vital*. However, these are in reality not explanations at all, but mere confessions of ignorance. To say that life evolves because of an *élan vital* is on a par with saying that a locomotive runs because of an *élan locomotif*.

Not only have the alternative explanations become implausible, but a great deal of new support has been forthcoming for the theory of natural selection. One of Darwin's difficulties about his own theory (which caused him to give greater weight to Lamarckism than he would otherwise have done) was that he could not see how new hereditary variations of small extent—what we to-day should call small mutations—could be preserved and kept from being swamped by crossing. This, as R. A. Fisher has pointed out, was due to his acceptance of the idea, current in his time, of "blending inheritance". In a cross between two distinct types, whatever constituted the material basis of heredity (and Darwin's generation completely lacked concrete knowledge on this subject) was supposed to blend in the resultant offspring, as two drops of coloured ink will blend with each other. Thus, any new character would be quite literally diluted on crossing

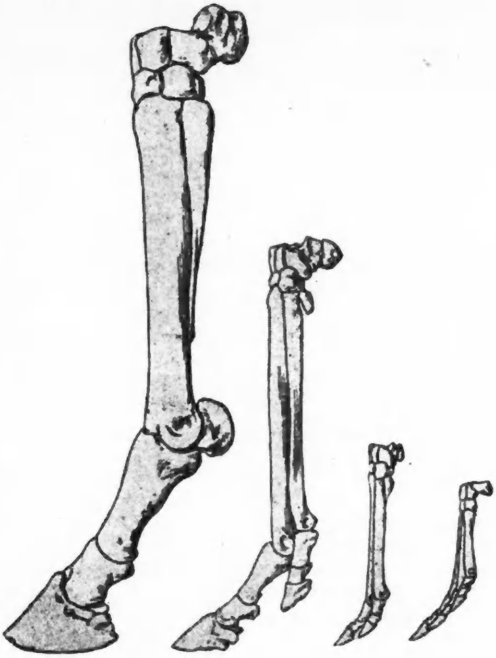


FIG. 1.—Four stages in the evolution of the horse's hoof: a series of left fore-feet to illustrate the evolution of the horse's hoof. On the right, early stage with four digits (three visible); next, three digits (two visible); next, three digits (two visible), but the outer two no longer in contact with the ground. On the left, one digit, the other two reduced to "splint bones". (Reproduced by kind permission of the authors and publishers of *Science of Life*: H. G. Wells, J. S. Huxley, and G. P. Wells, and the Waverley Book Co.)

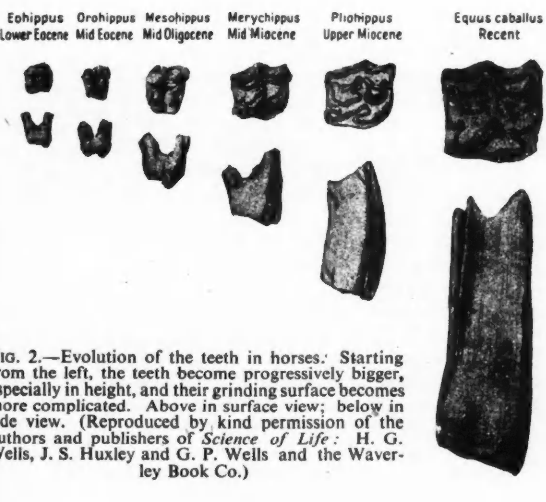


FIG. 2.—Evolution of the teeth in horses. Starting from the left, the teeth become progressively bigger, especially in height, and their grinding surface becomes more complicated. Above in surface view; below in side view. (Reproduced by kind permission of the authors and publishers of *Science of Life*: H. G. Wells, J. S. Huxley and G. P. Wells and the Waverley Book Co.)

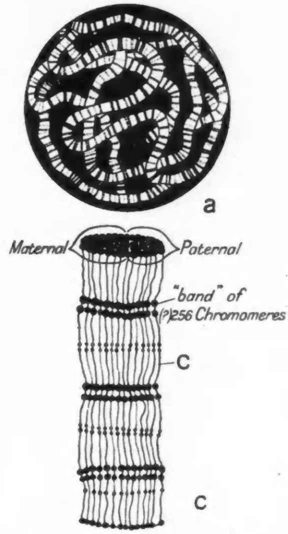
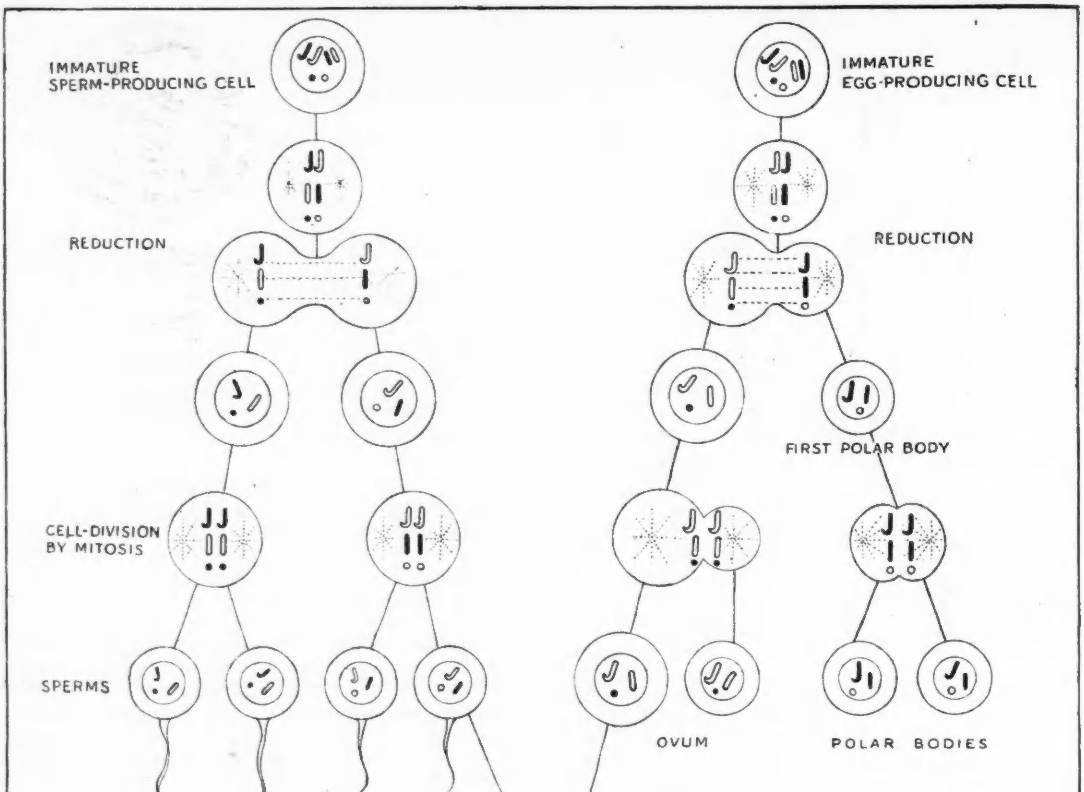


FIG. 3.—Diagrams illustrating the structure of chromosomes as seen in the chromosomes of the salivary gland of the fruit-fly *Drosophila*. (*a*) General view of a nucleus with the four pairs of chromosomes coiled within it. (*c*) Diagram of a portion of one chromosome magnified, showing the structure more in detail. The dark bands represent either genes or groupes of genes. (Reproduced by kind permission of the author and publishers of *The Chromosomes*: M. J. D. White and Methuen & Co.)

with the original type, and would soon fade out. The essence of Mendelism, however, is that the genes or units of heredity remain unchanged (apart from rare mutation) however they are combined with other genes. Many of the new genes produced by mutation can remain in the stock indefinitely until conditions are favourable, when they will begin to increase their representation in the stock. If a new mutant gene is recessive—i.e., must appear in double dose before it produces any visible effect—it can be carried in single dose for an indefinite period, even if it is slightly deleterious.

What is more, we now know that the effects of genes can be markedly altered by other genes, and numerous examples exist where slightly deleterious genes have been rendered harmless or even beneficial by being "buffered", in the chemist's phraseology, by new combinations of other genes. A beautiful example comes from domestic dogs. In producing the show type of St. Bernard, man has encouraged features characteristic of abnormal overgrowth of the pituitary gland: yet St. Bernards are not themselves abnormal, as a man with comparable characteristics would be. However, when St. Bernards are crossed with other breeds like Great Danes, a considerable number of the offspring show actual pathological symptoms. In producing his ideal of a St. Bernard, man has selected for genes making the pituitary abnormal: but he has also aimed at healthy dogs and so has automatically selected for other genes which would prevent the first genes from exerting any major harmful effect. But when these "buffering" genes are diluted or reduced in number by crossing, the potential abnormality of the pituitary can become actual.

This fact of recombination is the source of a whole category of variation unsuspected by Darwin; much that is new in evolution is due, not to wholly new genes produced by mutation, but only to new combinations of old genes.



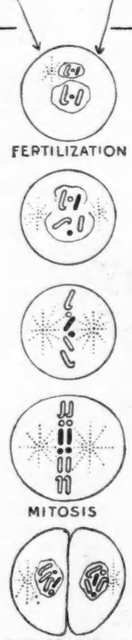


FIG. 4.—A summary in diagram form of how the chromosome outfit is handed on from one generation to the next. The species is supposed to have three pairs of chromosomes. Those derived from the animal's father are indicated in black, those from its mother in white. On the left, the formation of male cells or sperms, on the right, formation of eggs and the degenerate eggs called polar bodies. Below, fertilization and the first division of the fertilized ovum. (Reproduced by kind permission of the authors and publishers of *Science of Life:* H. G. Wells, J. S. Huxley, and G. P. Wells and the Waverley Book Co.)

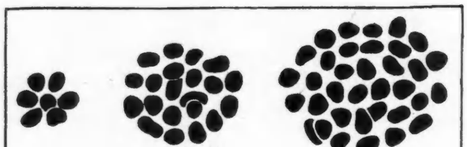


FIG. 5.—How a new species was made by crossing. Left, the reduced chromosomes of the Iceland Poppy, *Papaver nudicaule*; it has one set of seven in its pollen and eggs. Right, those of another kind of Poppy, *P. striatocarpum*; it has five sets of seven chromosomes in its gametes. Centre, those of their hybrid. The single set from the first parent mated with one set from the second, leaving four sets which mated with each other; all the pollen grains and eggs thus had three sets of seven. (Reproduced by kind permission of the authors and publishers of *Science of Life:* H. G. Wells, J. S. Huxley and G. P. Wells and the Waverley Book Co.)

Thus, most of the raw material of evolution is produced in the first instance by mutation of genes into new forms. Owing to the fact that they are not blended in crosses, this new variation does not have to be accepted or rejected immediately, but can be stored in reserve, so to speak. If not acceptable in itself, it can even be rendered acceptable by the recombination of other genes. And, in the second place, recombination of old genes is capable of producing a large further supply of new variation.

Still another fraction of the raw material of evolution depends on the fact that the genes are arranged in a row along a series of visible (but of course microscopic) thread-like bodies called the chromosomes (Figs. 3 and 4). Owing to accidents in cell reproduction, whole sets of chromosomes may be added or subtracted. Doubling of the normal complement of chromosomes is a frequent subsidiary method of evolution in plants. The polyploids, as the types with increased chromosome-number are called, are often more resistant to extreme conditions: for instance, polyploids constitute an unusually large proportion of the varieties found in the arctic and mountain regions that have become re-colonized since the retreat of the ice after the Ice Age.

Chromosome-doubling may also occur after a cross between two true species. In this case, a new species is formed at one jump—a process which would have shocked most of Darwin's nineteenth-century followers, who believed that all evolution was gradual. Sometimes such new types are weakly, and die out: in other cases the new combination of genes gives them exceptional vigour, and they may even oust both their parents. The classical example of this comes from the rice-grasses, *Spartina*, which live on mud-flats. During the last half-century, a new type of rice-grass appeared in Western Europe, and has been so successful that the Dutch have used it to reclaim land from the sea. Investigation has proved that this is a new polyploid species produced by the crossing of an original European species with one accidentally imported from America. In some areas the European species has been virtually exterminated by the new type.

Another instance is the crossing of the two poppies *Papaver nudicaule* and *P. striatocarpum*, the offspring of which are quite distinct from either parent, and are fully fertile and breed true, for reasons explained in Fig. 5.

Single chromosomes or groups of them may also be added or subtracted to give favourable results: a cytological accident of this sort gave rise, it seems, to the very successful branch of the rose family which later produced the apples and pears and their relatives.

Finally, bits of chromosomes may be shifted about. Small sections may be repeated, thus increasing the total number of genes available. Sections may be inverted, which tend to isolate the genes they contain from those contained in the uninverted section. Or chromosomes may exchange sections, a process which will help in the reproductive isolation of the new strain.

All these kinds of chromosome mutations, too, provide a source of variation unknown to Darwin, thus helping to account for the almost incredible profusion of distinct species in life (nearly a million in insects alone!). But the most important raw material of evolution seems to consist of gene mutations. In the early days of Mendelism the existence of mutation was taken to mean evolution by big jumps, and to run counter to Darwin's conception of steady and gradual change. This, however, was merely due to the fact that attention was, quite naturally, first concentrated on those mutations which could be readily detected—in other words, those with large effects. Just because they have large effects, however, they are apt to throw the hereditary machinery out of gear, and so not to be of much value for evolution. Later, it was discovered that the majority of gene mutations are of small extent, often quite difficult of detection save by the most refined techniques. And the accumulation of such small mutations, constantly buffered by new recombinations, will give precisely the type of change that Darwin had in mind. Evolution does go by jumps, but in most cases the jumps are so small that they hardly ever take the new type outside the range of variation already existing in the species, and the visible result is a gradual one. Discontinuity of variation is thus translated into continuity of evolutionary change: instead of a staircase, life marches up a ramp.

So much for the mechanism of evolution. But Darwin was almost equally unprovided with knowledge about the actual course pursued by evolution in different groups and in different conditions. He was aware of the fact that fossils from an earlier epoch differed from the modern inhabitants of the region, though resembling them in general type; he was aware that isolation might play a role in the production of new species; he knew of animal or plant groups which were on the border-line between a mere variety and an obviously "good" species; he worked out for himself some of the results to be expected of sexual selection (i.e. competition for mates between rival males). But that, with the indirect evidence provided by comparative anatomy and geographical distribution, was about all.

With this meagre body of knowledge at his disposal, his genius was able to put evolution on the map; but he could not proceed to the further task of mapping evolution itself. That was reserved for the slow cumulative work of several later generations of biologists.

It is not easy to sum up the chief results of that later work in brief and intelligible form; but it must be attempted. First, there is the formation of new species. These, we now know, originate in many different ways, and even those with the same origin may come to differ in size and internal structure. The chief method of origin is through physical isolation. Once two groups are physically isolated so that they can no longer interbreed, they inevitably come to diverge from each other in the new mutations and the new gene-recombinations which they accumulate under the influence of natural selection. And after a certain time the differences in their constitution reach such a pitch that, even if the two stocks are brought together once more, they are partially or wholly infertile on crossing.

In addition, when an isolated group is small in numbers, it can be shown on mathematical grounds that it is likely to pick up and incorporate some mutations and recombinations that are useless or even slightly unfavourable. Thus, some of the diversity of life is, biologically speaking, purely accidental.

The effects both of physical isolation and of small populations, are well illustrated by the plants and animals of islands. A population on an island is more or less

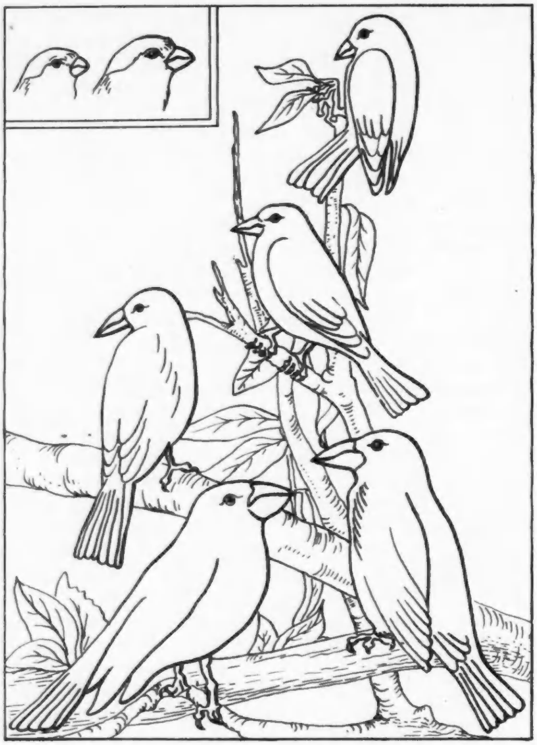


FIG. 6.—Isolation as a species-maker. Five species of ground-finches from different islands of the Galapagos archipelago. Note differences in size and especially in size and shape of bill. Inset, the heads of two subspecies of Bullfinch; to the left, the British subspecies, to the right, the Northern Bullfinch, found in Northern Europe, which is considerably larger and stockier. (Redrawn by kind permission of the authors and publishers of *Science of Life:* H. G. Wells, J. S. Huxley and G. P. Wells and the Waverley Book Co.)

completely isolated from other groups: and, accordingly, islands have a disproportionate number of distinctive subspecies and species, different from the species inhabiting the nearest mainland and from those inhabiting other nearby islands.

The extraordinary number of distinctive species of giant tortoises and of ground-finches on the Galapagos archipelago was one of the main facts met with by Darwin in his voyage on H.M.S. *Beagle*, which convinced him of the reality of evolution (Fig. 6). Again, there is only one form of mouse-deer on the whole of Sumatra and Borneo, while the Rhio-Linga archipelago close by, with only 1/150th of the area, boasts no less than seven distinct subspecies.

In the Adriatic a large number of islands have been formed by subsidence of the land since the end of the Ice Age. Many of them are inhabited by distinctive races of lizards. A recent study has shown that the smaller the island, and therefore the smaller its lizard population, the more different this has become from the mainland type from which it was originally derived (Fig. 7).

The other chief method by which new species are formed is through genetic isolation. This happens when a new form, wholly or partly infertile when crossed with its parent, is produced by some genetic accident—by means of the reduplication of whole chromosome sets, with or without previous species-hybridization; by means of the subtraction or addition of whole chromosomes; or, in some cases, by the breakage of chromosomes and the reunion of the pieces in new arrangements.

The result is an overwhelming multiplicity of distinct species. Naturally they are all adapted to their surroundings: but the geographical and cytological accidents that produced physical and genetic isolation causes their number to be much greater than that which would be necessary on purely adaptive grounds; and non-adaptive variation adds its quota to the diversity.

Most of evolution is thus what we may call short-term diversification. But this kaleidoscopic change is shot through with a certain proportion of long-term diversification in the shape of the long-range trends revealed in fossils by the palaeontologist and deduced from comparative studies by the morphologist. These trends are almost all of them one-sided specializations, each one exploiting a particular mode of life. Thus, both reptiles and mammals, beginning with small and generalized creatures, radiated out into specialized lines including carnivores, herbivores,

DIFFERENTIATION IN ISLAND LIZARDS

area (arbitrary units)	0–6	6–12	12–18	18–24	24–30	30–36 depth (m)
< 0·5	2½		2½			
0·5–1	1	1				
1–5	1, 2	1, 2	2, 2½, 2½, 3	3		4
5–10	1					
10–100	0		2			
100–1,000			0			

FIG. 7.—Table showing the influence of time and of size of population on the differentiation of island lizards from the mainland form. The depth is the maximum depth of water between the island and the mainland; as the islands have been formed by subsidence, the depth gives a measure of the time since isolation occurred. The area represents the area of the island, which is a measure of the population. The figures 1-4 in the chequer-board represent degrees of difference of the island forms from the mainland form. It will be seen that on the whole the longer the time of isolation and the smaller the size of the population, the greater is the degree of divergence. (Reproduced by kind permission of the author and publishers of *Evolution: the Modern Synthesis:* J. S. Huxley and Allen & Unwin)

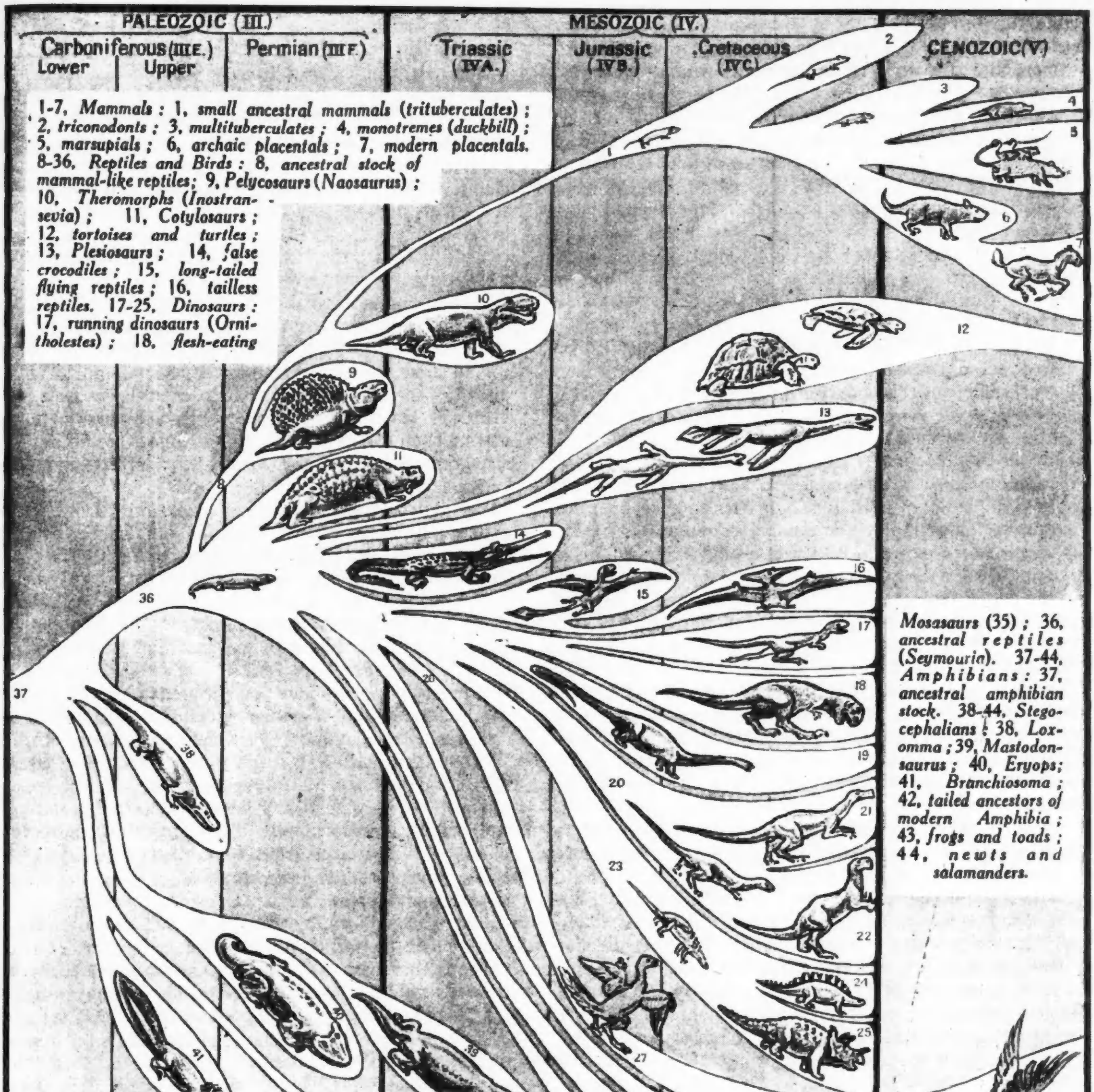


FIG. 8.—The evolution of land vertebrates, showing the specialization of numerous reptilian stocks and the extinction of almost all of them at the close of the secondary period. (Reproduced by kind permission of the authors and publishers of *Science of Life:* H. G. Wells, J. S. Huxley and G. P. Wells and the Waverley Book Co.)

climbing forms, flying forms and aquatic forms. Every possible niche is filled; some trends even involve degeneration, such as the trend of the barnacles from a free-living, shrimp-like creature to a sedentary life, or of other active crustacea to an existence as shapeless parasites.

These trends may continue for a very long time—up to tens of millions of years: but they always come at last to a dead end. After this, minor diversification may continue at the species level, but no further improvement takes place in the major specialization. Thus, birds ceased to show any improvement as flying mechanisms some 15 million years ago, and there has been no evolutionary improvement of the ant type for perhaps 25 or 30 million years.

Such trends in a given direction are to be expected on Darwinian principles. Improvement of teeth and claws for a carnivorous existence, for instance, will be an advantage to a small generalized mammal when there are no specialized carnivorous competitors already in the field, and will be favoured by natural selection. And once the type has become at all adapted to flesh-eating, it will be almost impossible for it to switch over to a herbivorous existence, for example: the number of mutations needed is much too great, and meanwhile any single mutation making for greater efficiency as a carnivore will be caught in the net of natural selection and incorporated in the constitution of the stock. The stock thus finds itself at the bottom of an evolutionary groove of specialization. Natural selection forces it farther along in the same direction, while constantly deepening the groove and so making it ever more impossible for the stock to escape out of it into some other way of life. The dead end comes when the specialization is so near its maximum possible perfection that selection cannot force the stock any further.

A third and still rarer type of change is evolutionary progress, which escapes the dead end awaiting specialization. It does so because its essence is all-round improvement, as opposed to the one-sided improvement that characterizes all specialization. It raises the general level of life's performance, instead of merely improving performance in respect of one particular mode of existence. The development of a head and brain or of a blood system were early steps in progressive evolution, while the acquisition of "warm blood" and so of a constant internal temperature, or the gradual development in mammals of higher mental faculties such as association and the capacity for learning by experience, are later examples.

The net result of evolutionary progress can be defined as the raising of the upper level attained by life in respect of certain very general properties—greater control; greater independence; greater harmony of construction; greater capacity for knowledge (and, we may probably add, for emotion). More concretely, it has permitted the rise of a succession of what the biologist calls dominant groups, because they spread and evolve rapidly, cause the extinction of many representatives of other groups, and play a new and predominant role on the evolutionary stage. The last three dominant groups in life's history have been the reptiles, the mammals, and man, each later one arising from an unspecialized branch of the one before. Most (or, in some cases, all) the branches of a dominant group undergo specialization, and then eventually come to a dead end, either by ceasing to evolve, or by the still deader end of complete extinction, as with most of the reptilian specializations, like the Dinosaurs, Ichthyosaurs and Pterodactyls (Fig. 8).

I said that progressive lines were rare. If we define progress strictly as capacity for unlimited further avoidance of dead ends, there has only been one progressive line in the whole of evolution—that which has led in its later stages through fish, amphibian, reptile and mammal to man; for it appears well established that all other lines have come to an evolutionary dead end well before the later part of the tertiary period.

Thus, in the broad view, evolution as a process consists of one line of unlimited progress among thousands of long-range trends towards specialization, each of these latter in turn beset with a frill, so to speak, of thousands of short-range diversifications producing separate species. Some of the peculiarities of these separate species are due to non-selective accidents; but all the rest have been closely guided and moulded by natural selection.

Darwin introduced time into biology, and forced us to regard human history as the extension of a general process of change, operating by an automatic natural mechanism. Darwinism to-day has fully confirmed these general conclusions, but has, in addition, enabled us to distinguish between different types of change, and to link up human with biological history more fruitfully by introducing the idea of progress and the criterion of desirable or undesirable evolutionary direction.

(To be continued)

Medical Advisory Committee to Minister of Health

A Medical Advisory Committee has been set up to advise the Minister of Health on the medical aspects of problems relating to the health of the people. The members of the Committee are:

The Presidents of the Royal College of Physicians, the Royal College of Surgeons, and the Royal College of Obstetricians and Gynæcologists; the Chairman of Council of the British Medical Association; Dr. G. C. Anderson; Dr. J. C. Arthur; Miss A. Bloomfield; Dr. J. A. Brown; Dr. E. Rock Carling; Dr. J. A. Charles; Prof. H. Cohen; Dr. W. Allen Daley; Lord Dawson of Penn; Dr. E. A. Gregg; Lord Horder; Sir Wilson Jameson (vice-chairman); Dr. W. S. Macdonald; Dr. A. A. Moncrieff; Prof. R. M. F. Picken; Prof. H. Platt; Dr. A. T. Rogers; Dr. D. O. Twining; Dr. O. Williams; and Miss A. L. Winner.

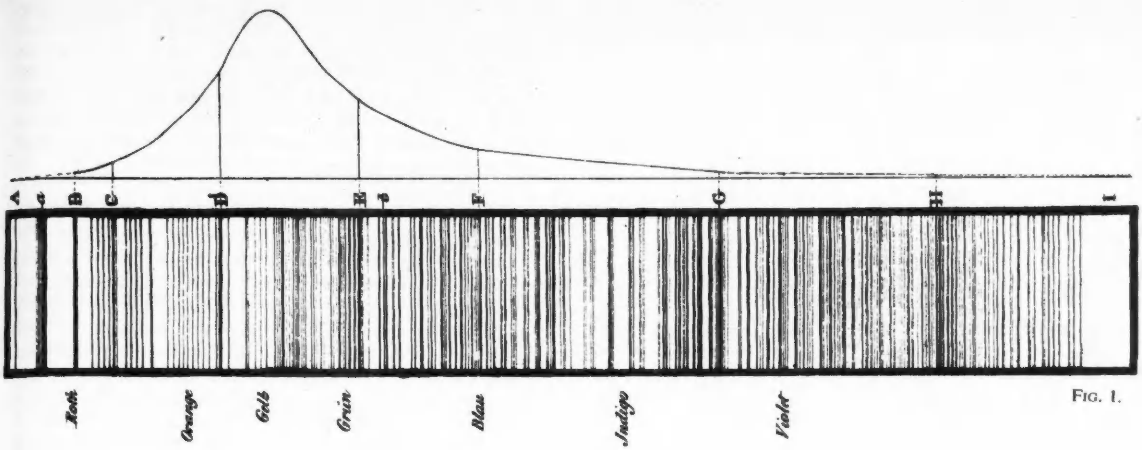


FIG. 1.

Spectroscopy: its application in Industry

By F. TWYMAN, F.R.S.

SPECTROSCOPY originated in experiments made by Isaac Newton with very simple means. He allowed a narrow beam of sunlight to come into a darkened room through a small hole in the shutter, and to pass through a prism of glass to a screen, on which it formed a strip varying in colour from one end to the other. He distinguished seven colours—red, orange, yellow, green, indigo, blue, and violet—and his experiments showed that these colours were not created by the prism, but were all present in the sunlight, the function of the prism being merely to separate them. The colours were differently refrangible, and this was why they were separated.

It was not till the year 1800 that the next step was taken, when William Herschel found that not only had the various parts of the spectrum different powers of heating bodies, but that an invisible part beyond the red end had a greater heating effect than any part of the visible. In 1801 this discovery was matched by Ritter who found that there was also an invisible part of the spectrum beyond the violet, the presence of which he demonstrated by placing there a piece of paper coated with silver chloride which was blackened not only by the violet, but also by this invisible ultra-violet radiation.

In 1802 it occurred to Wollaston to admit the sunlight not, as appears to have been the practice previously, through a round hole, but through a crevice, one-twentieth of an inch broad, and he found that the solar spectrum was then crossed by distinct dark lines.

In 1817 Fraunhofer set out to determine the optical properties of the various glasses. He required to know these properties to help him compute better achromatic object glasses for telescopes. With an assembly of slit, prism and part of a theodolite, including its telescope, he determined the positions of the lines of the solar spectrum by angular measurements on the circle of the theodolite, and drew a picture of them which is reproduced in Fig. 1. These lines are named after him, "The Fraunhofer Lines".

The same paper describes also the use of this—the first—spectroscope to make the first observation of metallic emission lines (the yellow doublet of sodium), and the first observations of the spectrum of a star, and of the electric spark. With it also he measured the refractive indices—that is, the power of bending the rays of light—for the principal lines of the solar spectrum. Probably no other paper in the whole literature of the subject records so great an advance on the instrumental side as does this one.

The yellow lines seen by Fraunhofer were not till long afterwards known to be due to sodium, or indeed to a metal. Even when W. H. Fox Talbot (1826 and more clearly in 1834) envisaged the possibility of chemical analysis by means of the spectrum, he did not realize that the lines he observed were due to the metals.

In an account of a number of brief, unconnected "Facts relating to Optical Science", Talbot (1834) includes the following statement:

"*On the Flame of Lithia*

"Lithia and Strontia are two bodies characterized by the fine red tint which they communicate to flame. The former of these is very rare, and I was indebted to my friend Mr. Faraday for the specimen which I subjected to prismatic analysis. Now it is difficult to distinguish the lithia red from the strontia red by the unassisted eye. But the prism displays between them the most marked distinction that can be imagined. The strontia flame exhibits a great number of red rays well separated from each other by dark

intervals, not to mention an orange and a very definite bright blue ray. The lithia exhibits one single red ray. Hence I hesitate not to say that optical analysis can distinguish the minutest portions of these two substances from each other with as much certainty, if not more, than any other known method."

This statement clearly establishes Talbot's right to be regarded as the discoverer of spectrochemical analysis.

Later (1836), in a further collection of "Facts relating to Optical Science" Talbot says: "It is much to be desired that an extensive course of experiments should be made on the spectra of chemical flames, accompanied with accurate measurements of the relative position of the bright and dark lines, or maxima and minima of light which are generally seen in them. The definite rays emitted by certain substances, for example the yellow rays of the salts of soda, possess a fixed and invariable character which is analogous in some measure to the fixed proportions in which all bodies combine, according to the atomic theory". He adds: "Silver-leaf deflagrated by galvanism gave a spectrum with several definite rays, among which two green rays appeared to me to possess nearly the same tint, although differing in refrangibility.

"Gold-leaf and copper-leaf each afforded a fine spectrum exhibiting peculiar definite rays. The effect of zinc was still more interesting; I observed in this instance a strong red ray, three blue rays, besides several more of other colours. These experiments were made in the laboratory of the Royal Institution in June 1834."

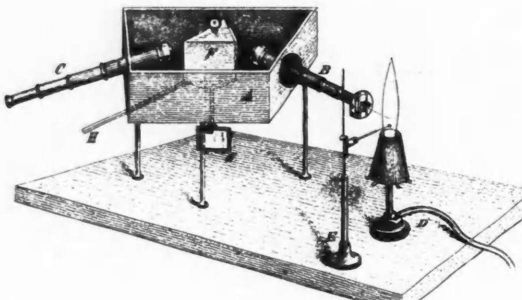


FIG. 2.

Wheatstone (1835) observed and made drawings of the spark spectra of sodium, mercury, zinc, cadmium, lead and tin, and states: " . . . the number, position and colours of the lines varies in each case; the appearances are so different, that, by this mode of examination, the metals may be readily distinguished from each other".

In 1842, Becquerel and Draper independently made another great step. They obtained photographs of the solar spectrum showing not only the Fraunhofer Lines in the visible part of the spectrum, but lines of a similar character in the ultra-violet. They used glass prisms (although three years later Draper took photographs with a grating); it was not until 1856 that a quartz spectrograph was described. This was due to William Crookes, and with it he took photographs of the spectrum in the ultra-violet.

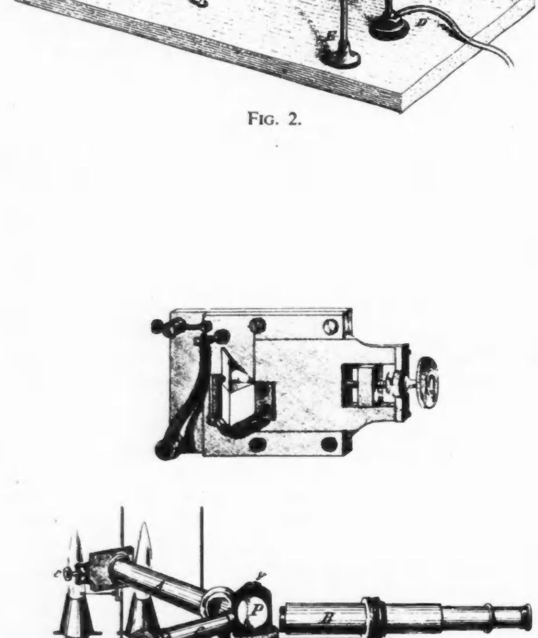


FIG. 3.

Then, in 1859 and 1860, Kirchhoff and Bunsen described a really practical spectroscope which would not occupy an unreasonable amount of space on a laboratory table (Fig. 2). The use of this instrument became customary in Bunsen's laboratory as a new aid in qualitative analysis. There had been plenty of statements previously that one could, from the spectrum, carry out a chemical analysis, but no one had given a satisfactory proof of it by actual experiment with the spectroscope on known substances. Till then investigators had been satisfied to try one or at most two salts of an element in the flame without settling definitely whether, for example, the red line which was obtained by the use of lithium chloride was due to the lithium or the salt. Kirchhoff in collaboration with Bunsen definitely settled this point. In the first of their publications on this part of the subject, Kirchhoff and Bunsen (1860) were concerned with the three alkali metals then

known: lithium, sodium, and potassium, and with the alkaline earth metals: clacium, strontium and barium.

Various salts of these elements were brought by them on a platinum wire into the flame; no matter what the salt, the same metals always produced the same spectra.

Finally, they also tried sparks between the electrodes of the metal, and found in the spectra so produced the same lines as in the flame, although accompanied by other lines, which they ascribed in part to impurities and in part to the nitrogen in the surrounding air. It was, they concluded, the metals present which determined the spectra of these flames.

The authors were able to announce that by the sensitiveness of the method they had already found a new member of the alkali group, namely, caesium.

Soon afterwards Kirchhoff and Bunsen were able not only to confirm the discovery of caesium (1861) but also the discovery by the spectroscope of a fifth alkali metal, rubidium. In this paper they state clearly that: "Among the great number of the salts we have examined which are suitable for spectrum analysis in the flame, we have not met a single one which, in spite of the great variety of the elements combined with the metals, has not exhibited the lines of the metals. One can therefore assume that in all cases the lines of the spectrum of a substance are entirely independent of the elements with which they are associated". The instrument used in these investigations is shown in Fig. 3. It is identical in its main features with many still supplied for chemical laboratories to-day.

Since that time there have always been a few chemists who had constant recourse to the spectroscope in their daily analytical work, yet as late as the year 1900 the original expectation that the new method would find general application in qualitative analysis had been lost sight of to such an extent that most analytical chemists never used a spectroscope at all; and it may be said that only in the last ten years has spectroscopy become a customary means of analysis and control in metallurgical production.

For some time after 1860, the attention of the scientific world was more intrigued by another aspect of Kirchhoff's work, first mentioned by him in 1859, when he described the phenomenon of the reversal of lines. He says: "Fraunhofer has remarked that in the spectrum of a flame there are two bright lines which coincide exactly with the two dark lines D of the spectrum of the sun. One gets the same bright lines, only brighter, in a flame into which one introduces common salt. I produced a sun spectrum and let the rays of the sun, before they fell on the slit, pass through a strong flame with common salt in it, and in place of the two dark D lines, two bright lines appeared. If, however, the sunlight is sufficiently bright the two dark lines appear much more distinctly, as if the flame with the salt therein had been absent."

Kirchhoff then describes how by using a lithium flame in the sun spectrum new dark lines could be seen, and continues:

"I deduce from these observations that coloured flames in whose spectra there are bright sharp lines weaken rays of the same colour as these lines when the same rays pass through those flames to such a degree that in place of the bright lines, dark ones are seen there, as soon as behind the flame a light-source of sufficient intensity is put, in whose spectrum those lines are not present. I conclude, therefore, that the dark lines of the sun spectrum, at least those which are not produced by the earth's atmosphere, indicate the presence of the same material in the sun's atmosphere as appeared in the same place in the spectrum of the flame.

"One can assume that the bright lines in the spectrum of the flame corresponding with the D lines of the solar spectrum originate from sodium. The presence of the dark lines D in the sun spectrum bring one to the conclusion, therefore, that sodium exists in the sun's atmosphere".

This was indeed a romantic find, and the discovery that one could determine with certainty what metals are contained in the heavenly bodies, soon gained the attention of astronomers. Many instruments were designed for use in combination with astronomical telescopes and a new and important branch of astronomy emerged—Astrophysics—the pursuit of which yielded in due course not only copious knowledge concerning the constitution of the sun, stars and nebulae, but information concerning their physical condition and movements.

Other workers turned their attention to the problem of precisely measuring the wavelengths of the various spectrum lines. Young (1802) had already explained the formation of the spectra by diffraction, using micrometer scales consisting of parallel lines 1/500th of an inch apart, and showed how to calculate the wavelengths of the lines by observations made with such diffraction gratings. Angström (1869), using gratings ruled by Nobert of Barth on a machine made by the latter, compared 1000 lines of the sun spectrum with lines of the elements occurring in the Earth, thus proving the existence of those elements in the Sun. He published them in a map which he called "The Normal Solar Spectrum", in which each line was placed according to its wavelength. The measurements covered the whole of the visible spectrum and were expressed in ten-millionths of a mm., a unit which was named the Angström Unit, now called the angstrom, and denoted by the letter A. His measurements of wavelengths were used for all spectral investigations until the publication of Rowland's tables in 1893.

The best of the diffraction gratings ruled by H. A. Rowland on the machine which he designed, have never been surpassed for definition. With them he measured the wavelengths of a large number of lines to an average accuracy of three parts in 10,000. This accuracy was improved, using methods of interferometry, by Michelson (1893) and by Fabry and Perot (1907). It is considered that Fabry and Perot's measurement of the wavelength of the red cadmium line is accurate to 1 part in 10,000,000.

Still another branch of physics, the theory of atomic spectra, sprang from attempts to find regularity in the distribution throughout the spectrum of the lines of the elements, attempts which in recent years have been extremely successful. The first regularity was discovered by Balmer (1885), who found that the wavelengths of the lines of the hydrogen spectrum formed a very simple series. Rydberg a few years later discovered a more general formula which can be made to fit series in every element.

Rydberg's ultimate purpose was to gain a knowledge of the structure of atoms and molecules. In pursuance of a similar aim, two principles of fundamental importance

were stated by Niels Bohr (1913) and can now be regarded as definitely established. These are:

(*a*) that atoms can exist only in certain states of energy.

(*b*) that when an atom passes from any one of these states to another, a definite amount of energy of a definite wavelength is emitted or absorbed.

It might reasonably be expected that the atom with the largest atomic weight, that is, with the largest number of electrons, would be the one capable of yielding the most complex spectrum, since the number of possible energy states would in that case be so much greater. The matter is, however, not quite so straightforward as that; we have to consider what variety of energy states can be produced by the means of excitation available.

A flame spectrum of a given element is always more simple than that of the arc, since the latter brings more violent influences to bear on the atom, while the electric spark, more violent still, causes the addition of still more lines to the spectrum. In these successive means of excitation we succeed in disturbing from their initial positions first one and then two, or even more, of the electrons that can be affected by these means of excitation.

But with a given means of excitation (e.g. a spark in air with a few hundred volts operative), it does not follow that a more complex atom, such as caesium (atomic weight 55), will necessarily give a more complex spectrum than, say, aluminium (3); in this case, indeed, the contrary is true. What determines the complexity of the spectrum is the number of electrons susceptible to the means of excitation employed, and the alkali metals lithium (3), sodium (11), potassium (19), rubidium (37), caesium (55), all give much simpler spectra than does iron (9).

Still more recently, the same principles have been established for the much more complex spectra of molecules, and a further vista opened up, revealing the possibility of studying molecular changes difficult to elucidate by chemical means.

The Spectrochemical Analysis of Metals and Alloys

Such, in broad outline, are some of the main developments resulting from the discovery of the spectroscope; but it is the main purpose of this article to describe the part played by spectrum analysis (or, as it is now usually called, spectrochemical analysis), in the present-day control of metallurgical production.

As has been pointed out above, after the establishment of spectrum analysis by Kirchhoff and Bunsen, the development of spectroscopy was carried on for some time mainly under the auspices of the physicist and the astronomer. For these it rapidly became an instrument of supreme importance. In academic laboratories, however, the spectroscope was chiefly used, if at all, as an intrument for teaching optics, and instruments were deliberately made with as many adjustments as possible, in order that students might learn the principles of the instrument rather than its use as an implement of research. Its present position in the field of metallurgical analysis is due to two causes, (*a*) the provision of instruments with which the chemist could take photographs not only in the visible but in the ultra-violet part of the spectrum, and without the necessity of himself performing laborious adjustments; (*b*) the technique of quantitative analysis acquired through the patient investigations of a host of workers from Lockyer (1873) up to the present time.

Almost all industrial spectroscopy in every country is now done by photography of the spectrum on a quartz spectrograph, and nearly all the instruments in general use follow very closely in optical design two instruments which were put on the market between the years 1909 and 1911 by the firm of Adam Hilger, Ltd., in London.

The smaller one, the Medium Quartz Spectrograph, is shown in diagram in Fig. 4. The radiation is provided by an electric arc or spark between two pieces of the alloy which is to be analyzed, these being held in a simple hand-feed stand A. The light from this is concentrated by the condensing lens B on the slit of the spectrograph D. The slit is a very important part of the instrument, and has to be made with great care, the two jaws being so accurately made that the edges may be approached to within one two-thousandth of an inch without any perceptible variations of width along the length of the slit. The radiation containing the whole of the rays characteristic of each metal present, passes through the lens E, called the "collimating lens", the purpose of which is to make all the rays fall at approximately the same angle on the quartz prism F, a condition for securing good definition. The spectrum formed by the prism is brought to focus by the camera lens combination G on the photographic plate H. The lenses and prisms are made of crystalline quartz, which is transparent to the ultra-violet rays to which glass is opaque. It is in the ultra-violet region that most of the distinctive lines of the metals are found.

This instrument photographs the whole spectrum from 2000 A to 10,000 A, the length of this spectrum being about 9 inches, and the whole of the spectrum is photographed simultaneously on the one plate.

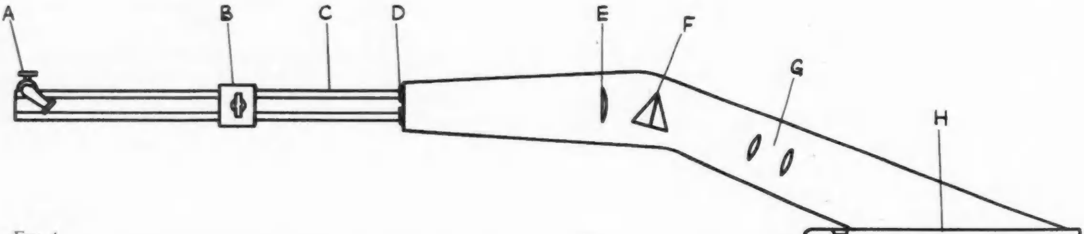


FIG. 4.

In the Large Quartz Spectrograph the spectrum is taken on a number of separate plates, since its total length is about 27 inches. Fig. 5 shows the simple holder for the specimens. With specimens of aluminium alloy, using a spark very similar to that which was used in wireless telegraphy, an exposure of *one minute* suffices to record the distinctive lines of *the whole metallic constituents of an alloy.*

Now that the reader has a mental picture of the process of taking the photograph, he should look at Fig. 6, which illustrates a simple case of qualitative analysis. The spectra shown are those of pure cadmium, commercial spelter and a supposedly pure zinc, and were taken to ascertain whether the spelter contained any cadmium. By seeking in the middle spectrum for lines which are absent from the bottom but strongly present in the top, one observes through the presence of the cadmium lines 3261·1, 3403·6, 3466·2 and 3610·5 that the metal is present in the spelter. The lines 3247·5, and 3274·0 which appear in all three spectra are well-known lines of copper and show that not only the cadmium and the spelter, but even the supposedly pure zinc all contain a small quantity of this impurity.

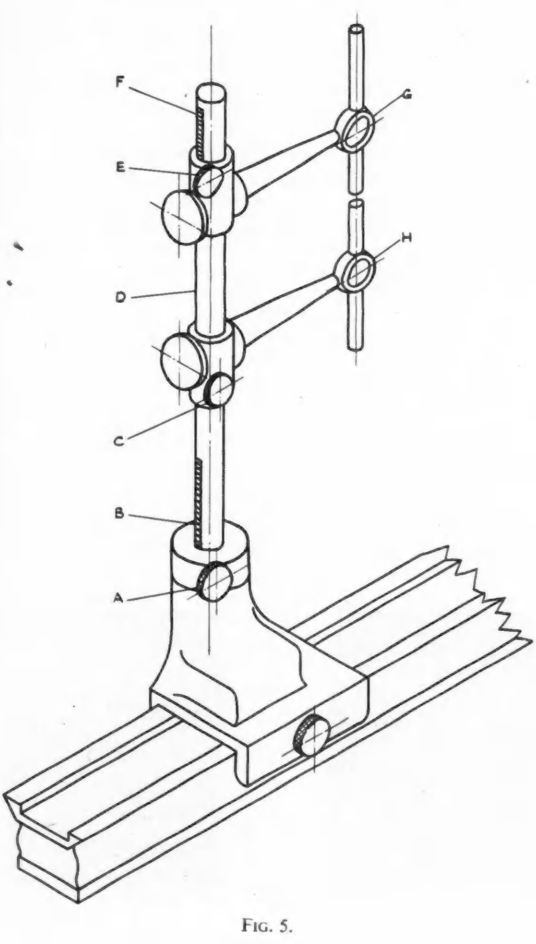


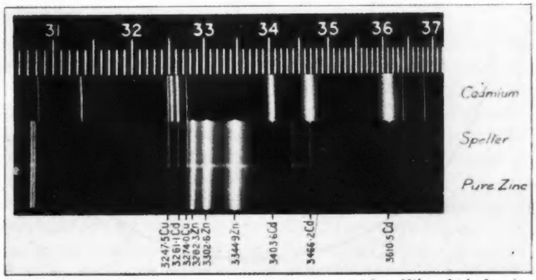
FIG. 5.

The Development of Quantitative Spectrochemical Analysis

Lockyer (1874) appears to have been the first to contemplate the possibility of a quantitative analysis based on spectroscopy. He says: "Quantitative analysis depends not upon their position"—the position, that is, of the lines of a minor constituent—"but upon their length, brightness, thickness and number, as compared with those visible in the spectrum of a pure vapour". Later in a section headed "The Experiments made on a Possible Quantitative Spectrum Analysis" he points out that "Since beginning with an alloy giving only the longest lines in the spectrum, by increasing the constituents other lines can be produced in the order of their length, the measurement of their length might give a measure of the quantity present". It will be seen that in the above passages, Lockyer adumbrates several possible quantitative methods, all of which have since been tried, but the one which holds the field to-day is a comparison of the brightness of the lines of the minor constituents with those of the main constituents of the substance, as compared with a similar comparison using a standard specimen.

Eight years after Lockyer's suggestion, W. N. Hartley, working with solutions, devised a method whereby he was able to get a rough idea of the quantity of a metal present by dilution of its solution to the point when the photographic lines of its spectrum were no longer recorded on the photographic plate. Hartley's work was continued from 1907 to 1909 in Hartley's laboratory by Pollok and Leonard, who both used substantially the same method as that of Hartley.

A. de Gramont did a very useful work over a long term of years by recording the most sensitive rays (*raies sensibles*), those lines, namely, which were still shown in a photograph when an element was present in very feeble quantity. With Gramont's list of sensitive lines before him, the worker can concentrate his attention on those wavelengths where the most sensitive lines occur and is thus saved the confusion resulting from the great multitude of lines present in complex spectra.



Adam Hilger Ltd., London

FIG. 6.

Judd Lewis (1916) was apparently the first to apply quantitative spectrochemical analysis as a regular means of analysis in industrial problems, and his method is still a very useful one, being applicable to all cases where it is easy to prepare synthetically a mixture containing the elements present in the substance to be analysed. The specimen to be analysed is brought into a standard physical and chemical condition (e.g. by ashing and sulphating), and by trial and error a synthetic mixture is produced whose spectrum exactly matches the specimen. Gerlach (1925) clearly enunciated a principle which is always referred to as Gerlach's Internal Standard Method, although it had been suggested many years before. In this method the lines of the minor constituents which are to be determined are compared with those of neighbouring lines due to the predominant metal. This procedure greatly reduces the errors arising from small variations of the intensity of the spectrum as a whole. Scheibe and Neuhäusser (1928) produced what one may call a wedge spectrum, by rotating in front of the slit of the spectrograph a sector as shown in Fig. 7. This produced spectra consisting of lines tapering to a point and it can be easily shown that the length of the lines on the photograph permit one to determine the relative intensities of the radiations themselves. It has been claimed that the accuracy in determining a minor constituent by this method is within about 10% of the constituent. Thorne-Baker had suggested the use of a stepped sector for a similar purpose in 1925.

We must omit other methods, of which a variety have been put forward from time to time, to come to the one which is in most general use to-day.

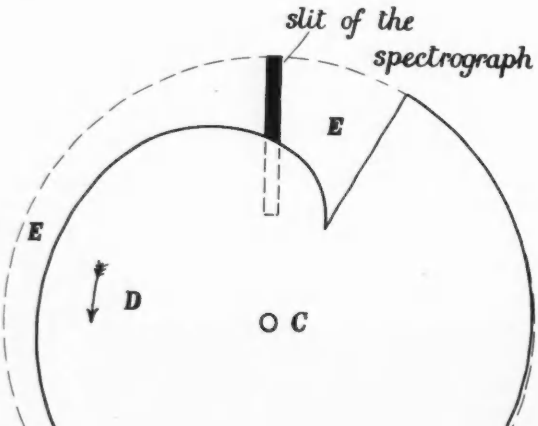


FIG. 7.

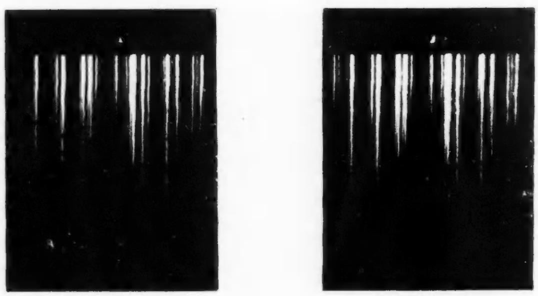
In this a microphotometer is employed, by means of which the blackening of the various lines of the spectrum of a specimen under test can be measured by means of a photoelectric cell and galvanometer. Measurements are made on a line of the main constituent and on a neighbouring line of the constituent to be determined and the ratio recorded. If on the same plate are recorded similar spectra of alloys of the same type, but with varying known amounts of the minor constituent, one can, by plotting these ratios against the known percentages, prepare a graph from which the percentage in the unknown specimen can be read off (Fig. 8).

Such, in principle, is the method chiefly in use in Great Britain to-day, a method by means of which millions of analyses are being carried out yearly with an accuracy sufficient for passing specimens to specification.

The method is by no means confined to the analysis of substances in the metallic state, and is in wide use for the analysis of plant and animal fibres, soils, minerals and many non-metallic industrial materials.

For example, it is desirable to control the slow changes in the concentration of the several alloying constituents in cast iron while still molten in the furnace. If these are to be maintained within narrow limits of tolerance, the time elapsed between taking a sample of the molten iron and obtaining the analysis should be very brief, otherwise a control of the constituents is not provided and only an inspection analysis results. Vincent and Sawyer have developed a technique which permits them with the spectrograph to obtain the analysis of a sample of cast iron for six elements (chromium, copper, manganese, molybdenum, nickel and silicon), within seven minutes, with an accuracy at least as great as that of the routine wet methods previously used.

Perhaps at the present time there is no metallurgical problem more important than the proper control of the various aluminium alloys used for aircraft, and the requisite analyses are now almost wholly carried out by the spectrograph. The various modern aluminium alloys combine with the common property of lightness very different properties appropriate for correspondingly different purposes, and their analysis by chemical methods is very laborious. An analysis which by the former chemical method will not be completed in less than twenty-four hours can, by the spectrograph, be completed within less than one hour.



Steel No. 11. Steel No. 14.

FIG. 8.—Spectrograms of two steels.

An application of very great importance at the present time is the examination of scrap. Since aluminium alloys differ so much in their properties according to constituents, it would obviously be disastrous to melt up aluminium scrap without separating the different types of alloy, for there would be no practical way of separating out the constituents subsequently. The same may be said of alloy steels. It is not surprising, therefore, that the spectrograph is playing a very important role in the examination and sorting of scrap. Among other applications of prime importance in metallurgical production at the present time, are the control of high purity copper, lead and its alloys, including the important ternary alloys of lead used for cable sheathing, the magnesium alloys, pure nickel and the zinc base alloys.

* * * * *

It is desirable to state here the limitations and the advantages of the method. It is in practice confined to the detection of any of the metals and of the non-metals arsenic, selenium, silicon, telurium, boron, carbon and phosphorus. In theory there is no such limitation, but since the most sensitive lines of many of the non-metals are of wavelengths shorter than 1850 A, at which air becomes almost completely opaque, to deal with such non-metals requires a vacuum spectrograph, and although these are in use for physical investigations, the difficulties involved in vacuum technique preclude their use under the normal conditions of a metallurgical laboratory.

Accepting this limitation, nothing rivals spectroscopy for detecting, without the necessity of separation, minute quantities of metals present in any element, compound or mixture, while in the case of metals and alloys, quantitative estimations can usually be carried out with an accuracy amply sufficient for passing specimens to specification. It may be said to-day that with metals and alloys the accuracy in determination of the minor constituents varies from about 2 to 7% of the amount of the constituent present. The sensitiveness of the method is very great and may be driven in the detection of most elements down to percentages as low as 0·001 or even less, while complete analysis requires the consumption of only an extremely small quantity of the substance.

Speed is one of the major advantages of the spectrograph and this is specially remarkable when the corresponding chemical analysis is difficult. For example, to determine by chemical methods such small quantities of cadmium and lead as are of interest in the production of high-grade zinc, is very tedious, the solution of the zinc is slow and the multiple precipitations necessary for the complete separation of cadmium are so laborious that the chemical analysis may take some days for completion. With the spectrograph it is possible for those in charge of the process to know within a few minutes of sampling whether the metal being produced in their plant is conforming with the stringent guarantees usually given for this class of material.

BOOKS—

S. Judd Lewis, *Spectroscopy in Science and Industry.* An introduction to practical emission and absorption spectroscopy. Published by Blackie & Son, Ltd., London.

W. R. Brode. *Chemical Spectroscopy.* The best general text-book for chemists on emission and absorption. Published by John Wiley, New York, and Chapman & Hall, London.

F. Twyman, *The Spectrochemical Analysis of Metals and Alloys.* An account of the methods in use in industrial laboratories for the analysis of metals and alloys. Published by Charles Griffin & Co., Ltd., London.

Isaac Newton's Apple Tree

With the financial help of the Pilgrim Trust, the Royal Society is to purchase Sir Isaac Newton's orchard at Woolsthorpe, near Colsterworth, Lincolnshire, in which is an old apple tree descended by direct grafting from the tree which awakened the scientist to a realization of the laws of gravity. With the orchard the Society will acquire the adjoining farm house where Newton was born 300 years ago.

It was announced at the 280th meeting of the Royal Society held in London that the Trust will finance the purchase for the Society. The meeting of the Royal Society was combined with the celebrations of Newton's birth on Christmas Day, 1642.

In his presidential address Sir Henry Dale said that it had seemed to the Society that something should be done to preserve for posterity a house and garden which carried such momentous memories and which had meant so much for science.

Dr. E. N. da C. Andrade, Professor of Physics at London University, and one of the scientists appointed to help the Ministry of Supply, said "If Sir Isaac Newton had achieved in this age what he did for his own he would have appeared as an Einstein, a Governor of the Bank of England, and a whole lot of other famous people all rolled into one."

Sir James Jeans said that the science of everyday life was still wholly Newtonian. Newton was no freak genius, but the concentrating embodiment of all the distinguishing characteristics of British science. "He created a system which, although philosophically unsound, was destined to endure for two centuries before any chinks were found in its armour."

Newton's ability as a skilled amateur mechanic and a notebook of his boyhood recording "methods of performing some (rather nasty) conjuring tricks," were recalled by Lord Rayleigh.

An exhibition of Newtonian books is being held at Wigan Public Library.

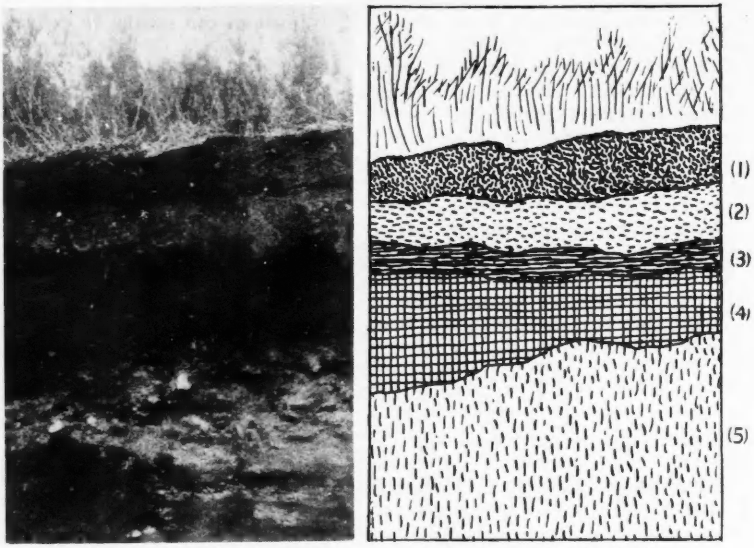


FIG. 1.—Podzol profile: (1) Surface layer (largely plant remains); (2) Grey layer (chiefly whitish sand); (3) Iron hard pan; (4) Hard compact layer (slightly cemented with iron); (5) Parent material from which the layers above were formed.

A Scientist at work on the Soil

W. G. OGG, M.A., Ph.D.

THE study of the soil has been going on from the time man first began to till it, from the very beginnings of civilization. In fact, tillage was perhaps the first great discovery about the soil made by primitive man. He found that, besides burying weeds and providing a seed-bed, turning up the soil and exposing it to the air made crops grow better. Probably the first tillage implement was the branch of a tree and through the ages the plough was developed, first the wooden plough, then the iron plough and all the host of cultivation implements of to-day.

In some places, cultivation alone was not enough. The land was wet and a ditch had to be dug to carry off the surplus water. From the open ditch we pass to the covered drain with the channel kept open by brushwood or stones, and, in more recent times, by tiles. But our early ancestors knew something more about the soil. They found they could grow bigger crops if they applied dung, and those near the sea often used sea-weed. Liming, too, is a fairly old practice and marl, shell-sand, chalk and lime were all used. Where it was necessary, they fallowed their land to rest it, clean it and improve its tilth or physical condition. In some places, they made their light soils heavier by applying clay, and in dry countries, flooding and other forms of irrigation were widely practised.

It is evident that long before the days of organized science, a considerable body of knowledge existed about the soil, particularly about its agricultural utilization. Farmers had found that by doing certain things crops grew better, but in most cases they did not know the reason for their practices. Modern science has explained, or is trying to explain, these empirical practices and why the crops grow better. This knowledge has led to fresh discoveries and has, in the last century, brought about vast increases in food production.

The aim has not always been purely utilitarian. Soils have been studied as a branch of natural philosophy for the sake of increasing our knowledge of the environment in which we live, and the term pedology, from πέδον—ground or earth, has been proposed for the science of the soil. It is concerned with the study of the surface geology and particularly with the processes of weathering. It also involves physical, chemical and biological investigations of a complex colloidal system.

Types of Soil and their Distribution

There are many different kinds of soils and there are several reasons for the differences. The character of a soil depends to a considerable extent on the nature of its parent material and hence ultimately on the rock from which it was formed. Some rocks are hard, others are soft; some contain a great deal of potential plant food and others contain very little.

A second reason why soils differ from each other is that they have been formed in different ways. Some result from the decay of the rocks over which they lie, whilst others arise from material carried long distances by wind, water or ice, agencies which also affect the shape, size and distribution of the rock particles. For instance, we have on the mountain slopes, shallow soils with coarse rock fragments, and in the river valleys deep alluvial soils of more uniform texture.

Topography and micro-relief also play an important part; soils developed on flat ground or in hollows, under conditions of impeded drainage, are quite different from others where drainage is free, even though the parent material is the same.

Then we have the effects of climate and vegetation on soil development and, in considering the world distribution of soils, they are the most important and fundamental factors. Soils developed in a cool moist climate differ markedly from those in a hot dry climate, even though they have arisen from the same type of rock. Vegetation affects the amount and kind of humus and this affects other phases of development. The influence of vegetation is really indirect as in a general way vegetation is a result of climatic factors; the soil in turn influences the vegetation. Other factors which have to be taken into account are the age of the soil and, in many cases, erosion and the influence of man.

These factors find expression in the soil section or profile and from the study of the profile it is possible to classify and map the different types. A general system has been evolved by which soils are divided into broad world groups, such as podzols, brown earths and tschernozems or black earths, and within these broad groups there are numerous sub-divisions. In the broad grouping, climatic factors are generally most important, whilst in the detailed sub-division, geology perhaps carries most weight.

In studying soils attention must not be confined to the surface layer. The whole vertical section (usually termed the profile), from the basal unweathered material to the surface soil, should be examined. This is generally composed of layers of different appearance, termed horizons, and a detailed study of these layers has to be made both in the field and in the laboratory. Fig. 1 illustrates the profile of the commonest soil type in this country, the podzol. The dominant factor in the development of the podzol profile is the prevalence of intense leaching owing to the excess of rainfall over evaporation, and this type is widespread throughout the world in cool humid climates. In the typical podzol there is a grey ashy leached layer below the surface and the name is derived from the Russian word "zola" meaning ashes. Certain constituents which are washed down cause cementation of the layers below.

Soil surveys have been carried out in many parts of the world, particularly in America and in Russia. In Britain, comparatively little detailed work has been done but the nucleus of a soil survey organization has been set up and more rapid progress will now be made. In the field, mapping is done on the basis of the soil profile and in the laboratory, chemical and other determinations are carried out to establish the properties of the types mapped and to assist in correlation. Soil classification and mapping provide a basis for further scientific investigation and enable farmers to apply the results of experiments to their own land.

The Living Nature of the Soil

One of the most striking scientific discoveries about the soil is its living character. A healthy soil is not a mass of dead particles but contains, besides earthworms and other creatures which can be seen, millions of bacteria and other invisible micro-organisms. Some of these play an essential part in the feeding of plants by taking nitrogen from the air and by making available the nitrogen compounds supplied in manures. The rotting or decay of dung, and plant and animal remains is due to bacteria, and it is because of their absence that peat forms. Plants of the clover family require certain bacteria in their roots for healthy and vigorous growth. These are usually present in our soils in this country, but when we come to grow a new crop, such as lucerne, for the first time it is advisable to inoculate the seed with the suitable organism.

The importance of bacteria and other living things, in the soil, is very great, and we should try to secure a vigorous and healthy population of the types which maintain or increase fertility. In ill-drained soils the living population is small and of an undesirable kind, and drainage and cultivation, by allowing air to get into the soil, favour the desirable kinds of micro-organisms. Soil sourness must be avoided so the possible need for liming should be borne in mind, and the soil should be suitably manured. There is still a great deal to be found out about the living things in the soil, and research workers are busy at this problem.

Physical Conditions in the Soil

Take another branch of soil research:- the study of the physical properties of the soil, such as texture and water holding power, which bear on the farmer's work of cultivation and draining. Tilth has a great influence on crop production and much research work has been done on the factors which affect tilth and on methods which produce a nice free-working crumbly soil. The amount of lime in the soil may affect its tilth, and the benefits of dung and green manures in keeping the soil in a good physical condition are well known. Then, we have the production of good tilth by the use of cultivation implements. Here again the soil research worker in co-operation with the agricultural engineer can help to devise better implements. The resistance which various soils offer to cultivation implements can be measured by the dynamometer, and the information obtained is used in designing ploughs and other implements. It was shown, in one experiment on ploughing, that an increase in speed from 2½ to 4 miles per hour increased the drawbar pull by only 7%, and enabled a 60% greater area to be ploughed in the time. Mention should also be made of new types of cultivation implements, such as cultivators of the rotary type and the gyrotiller.

The scientific study of draining has been rather neglected in this country, and the depth and distance apart at which drains are laid is still a matter of judgment rather than measurement. But the judgment, even of an experienced practical man, is not infallible, and some other countries have found it worth while to attempt to convert the art of

draining into a science. The soils are tested in the laboratory and the results, together with information on levels and rainfall, used in drawing up drainage schemes. A good deal of experimental work has also been done in recent years on mole draining, and on draining machines to cut down the cost of digging trenches.

Liming and Manuring

The greatest benefits the farmer has obtained from modern soil research, however, are with regard to liming and manuring. Liming is an old practice, but in the past it was carried out in the rule of thumb way without a proper understanding of its effects. It was usual to apply very heavy dressings of lime when land was reclaimed and afterwards at long intervals, but in many cases the dressings were unnecessarily heavy and at times so heavy that they were harmful. Instances of overliming are quite common on the coast in the neighbourhood of shell sand deposits, but most farmers err in the other direction and are neglecting to lime land which is badly in need of it. Over great parts of Britain the crop yields are definitely curtailed because of the lack of lime and, as well as reducing yields, acute deficiency in lime affects the feeding value of the crops and this in turn affects the stock. In particular, much of the grazing land of the country would benefit from liming.

The farmer can sometimes tell that his soil requires lime from the failure or unsatisfactory growth of certain crops—for instance, sugar beet, beans, peas, barley and clover, particularly red clover, and from a patchy appearance in the colour of the herbage. Indications are also given by certain weeds, such as sorrel, spurrey and corn marigold, by the occurrence of finger and toe in turnips, by yellow mottling and brown spots on the leaves of plants, and by stunted root development.

There are, however, many soils which are not so sour as to produce these symptoms, but which would benefit from a dressing of lime. Besides, the farmer wishes to know not only whether lime is required but how much. Lime is not by any means cheap, and no one wants to apply more of it to his soil than is necessary for the satisfactory growth of his particular crops. A farmer growing oats, turnips and pasture does not require so much lime in his soil as a farmer growing such crops as sugar beet, wheat and barley.

The soil chemist can help the farmer by testing his soil and telling him whether it requires lime and also how much to apply, taking into account the crops to be grown. There are two main types of methods used. In one, an estimation is made of the amount of lime required to bring the soil to a satisfactory lime status as measured by degree of acidity; in the other, the readily available lime in the soil is determined and if this is low, an appropriate dressing is given.

Soils can also be tested for manurial requirements and valuable help given to the farmer, though it is rather more difficult to tell the exact quantities which should be applied. As a matter of fact, the whole of the artificial fertiliser industry has been built up on the discoveries of research workers during the past century. It was the scientist in the laboratory who discovered how plants feed and what they get from the soil and what from the air. It was the chemist who found, on analyzing plants, that their ash contains phosphate, potash, lime and other things. This discovery led John Bennet Lawes, land-owner, farmer, and man of science, to treat bones with sulphuric acid and produce the first superphosphate. He also laid out the famous field experiments at Rothamsted to test out the effects of various manures. That was nearly a century ago and a few years earlier it had been shown that the growth of plants was improved by sulphate of ammonia, a waste product from gas works. Mention should also be made of the guano industry, the nitrate deposits of Chile, the potash deposits and the use of ground rock phosphate, both in the manufacture of superphosphate and as a direct manure. Then we had the introduction of basic slag, a by-product of the steel industry, and the more recent production of nitrogenous manures from the nitrogen of the air. Agricultural research had brought from industry a perfect avalanche of substances to feed the crops. The farmer was overwhelmed with new manures and it is not to be wondered at that for a time he suffered from manurial indigestion. Which of these substances was he to use, when should they be applied and how much should he give to his various crops? Scientific workers have been helping him to answer these questions, and are still helping him. The chemist has been analyzing the manures to control their quality and to see that he gets value for his money; the soil worker has been studying the different kinds of soils to find out what are their deficiencies and what type of fertilizer suits them best. In addition to laboratory work, experiments have been carried out in pots and in the field to find out how the plants respond to the different manures (Fig. 2). Valuable information has been obtained as to the most suitable types for different purposes, the amounts which should be used, and the best times to apply them.

In this moist climate of ours, some of the lime and manure applied to the soil passes through it and is washed away in the drainage water. These drainage losses have been studied in various parts of the world. At Aberdeen, for instance, where investigations have been going on for more than twenty years, blocks of soil each 1/1000th of an acre in extent, were enclosed by means of slate slabs and all the drainage water which comes through has been collected and analyzed every month. It has been found, in this particular soil, that there is a considerable loss of lime, but under the normal cropping and manuring practised in the district there is little loss of potash and nitrogen, and practically no phosphate is washed out. Some of the phosphate, however, becomes locked up in the soil in a form in which plants cannot use it. There are still many problems of this kind to be solved in the complicated business of manuring, but most farmers have now got a good grasp of the essentials.

Even the most intelligent farmer, however, must often find it difficult to decide how to manure his fields, for soils differ greatly in their needs and past treatment plays a big part. If he is fully satisfied with his crops, the farmer asks himself: "Am I adding more manures than necessary and wasting money?" If his crops are unsatisfactory he says: "What should I add to improve them?" It is impossible to tell by looking at the soil, but some idea may be got from the appearance of the growing plants. For example,

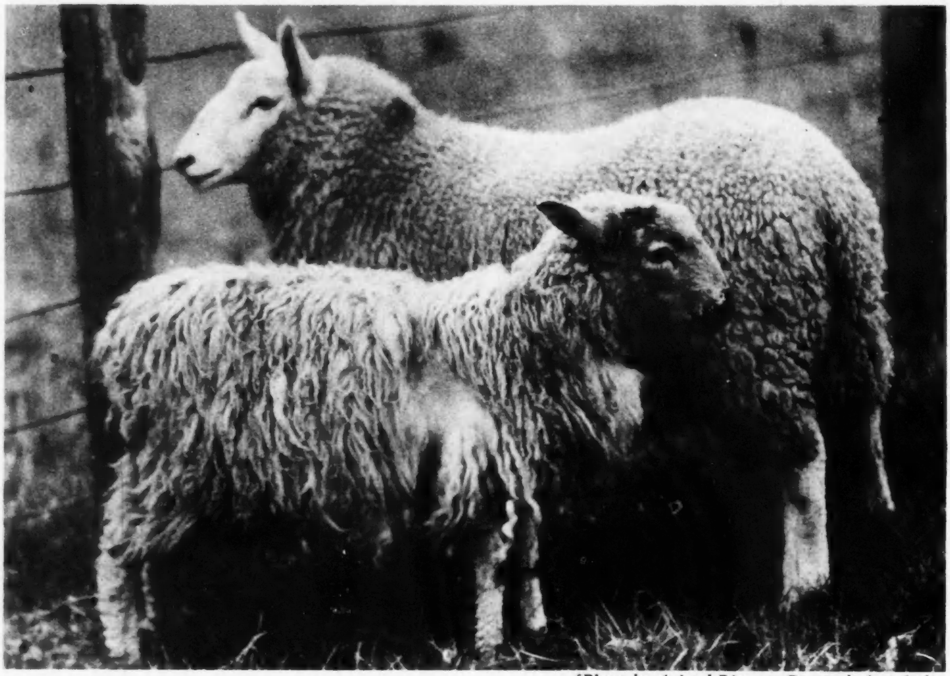
FIG. 2.—Pot experiments for the estimation of manurial requirements.

FIG. 3.—Soil testing for advisory purposes. Determining the pH and "available" phosphate.

the yellow striping of the leaves of cereals or lack of clover in pasture may indicate potash deficiency. Stunting of the plant, poor root system, lack of tillering, purplish colour of leaves and stems, and delayed ripening may suggest phosphate deficiency. It is difficult, however, to get even an idea of what is lacking to say nothing of the quantity required. Methods of soil testing have now been developed which provide useful information as to the kind and amount of fertilizer the farmer should use (Fig. 3). In carrying out a soil test, samples are taken from various parts of the field by means of a spade or preferably an auger. The sample must be representative of the field or portion of the field and not be taken from a single spot. The soil sample is then examined in the laboratory. Various methods of testing are employed but usually the soil is shaken up with a weak acid which extracts the more readily available plant food, and the empirical results obtained are interpreted in the light of data accumulated from pot tests and field experiments. Soil testing is carried out at agricultural advisory centres in various parts of the country and all the farmer requires to do is to apply for help to his local county organiser. Either his soil will be sampled for him or he will receive instructions how to take a sample himself, and when the soil examination has been carried out he will receive a report indicating the manurial treatment considered necessary. A good many farmers have their soils examined regularly but it is surprising how many either do not know that these facilities exist or do not trouble to take advantage of them.

No mention has yet been made of farmyard manure, but these artificial fertilizers, though very valuable as supplements, have not done away with the need for it. Modern soil research has shown its value more clearly than ever, and the farmer should use as much of it as possible, and should take care that its valuable ingredients are not washed down the drain. But there is not sufficient farmyard manure to go round and it has to be supplemented by artificials.

In dealing with manuring, reference should be made to substances which are required by plants only in minute traces. Boron is an example of this and lack of boron in certain soils is responsible for a disease called crown rot in sugar beet and for raan, a disease in swedes. Deficiencies in magnesium and manganese in certain soils have given rise to crop failures and a form of "pining" in sheep and cattle (Fig. 4), which occurs in some places, has now been shown to be due to a deficiency in cobalt, although for a time it was thought to be caused by lack of iron. The amount of cobalt necessary in the herbage is less than one part in ten millions and it has been found that pining in sheep due to cobalt deficiency can be prevented or cured by applying to the soil dressings of 2 lbs. per acre of a



[*Photo by Animal Diseases Research Association.*

Fig. 4.—Pining due to cobalt deficiency. The pining lamb is the same age as the healthy.

cobalt salt. In determining such small quantities of materials, use is now made of spectrographic methods (Fig. 5). A small amount of soil, or an extract of it, is burned, a photograph is taken of the spectrum and, by measuring the intensity of the lines, quantitative determinations can be made of materials present in minute traces.

Soil Erosion

Lack of knowledge sometimes leads to disastrous mistakes and some of the world's most fertile regions have been turned into barren wastes through mismanagement. In many parts of the world the surface soil has been washed away by water or blown away by wind leaving only bare rock or a barren subsoil. This is known as soil erosion, and it has already ruined millions of acres of land. The soil is swept away and and cannot be replaced, but that is not all, for when the porous surface soil, which can absorb the rain, has gone, floods are apt to occur and huge gullies are carved out in the land. This may affect the underground water, and dry up the wells and water supplies. In some regions the soil, which is washed into the rivers, silts them up and causes them to overflow their banks at certain seasons. The effects of soil erosion are, therefore, far-reaching and disastrous and the annual damage due to it in the United States of America alone, has been estimated at 400 million dollars. It has ruined great regions in Canada, and is doing irreparable damage in South Africa, Australia and other parts of the world, particularly in warm dry countries.

There are various things which can bring it about and one of the most common is unsuitable types of farming. In the Canadian prairies it has been caused by growing wheat year after year. The humus which helps to bind the soil together has been used up and the powdery soil which is left is readily blown away or washed away, especially when the land is lying fallow. In order to check it, many Canadian prairie farmers now practise mixed farming for in this way they can keep up the supply of humus in the soil. In some parts of Australia a common cause of erosion is over-grazing, the grass being eaten down too far and the bare dry soil blown away. In other parts of Australia the wheat land is being eroded rapidly during the periods when the soil is lying fallow.

Soil erosion is one of the most serious agricultural problems in the world to-day, for if it goes on unchecked we may be faced with famine. An exhausted soil can be retored to fertility by suitable manuring, but an eroded soil has gone for good. The seriousness of the situation has been realized in many countries, however, and active measures are being taken to cope with the problem. In some regions the land on slopes is built into a series of flat terraces, in order to check the downwash of soil. Ploughing round the slopes instead of up and down—what is known as contour ploughing—is another remedy

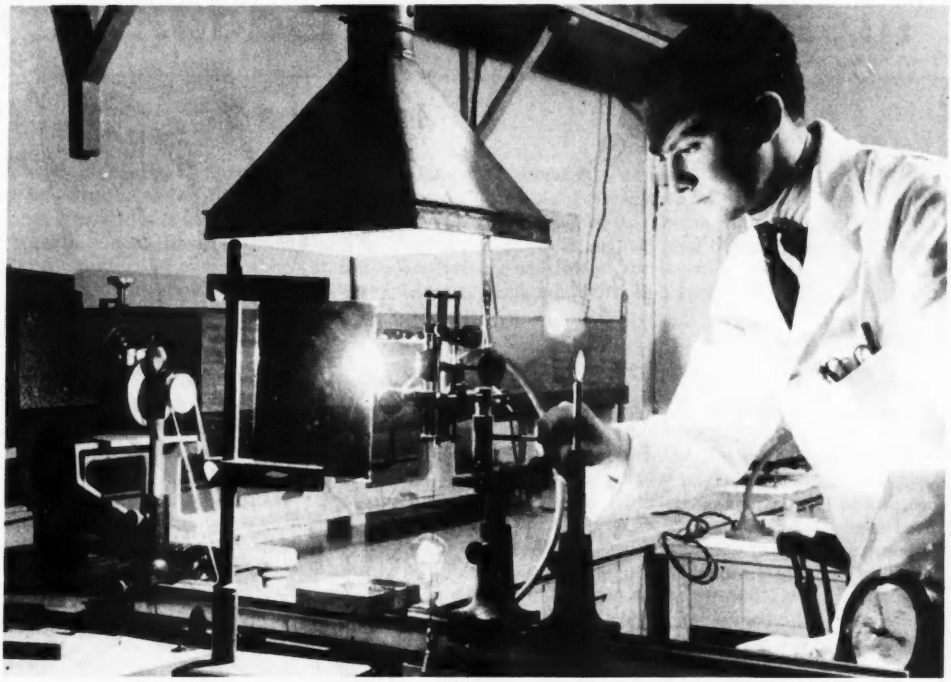


FIG. 5.—Estimation of trace elements in soils by spectrographic methods.

and, as already mentioned, it is important to keep up the supply of humus in the soil. As erosion takes place to the greatest extent when the land is bare, another obvious remedy is to have it covered with vegetation, but this is not always possible. Every country must solve its own erosion problems; and to do this it is necessary to make a thorough study of the soil and to practise a system of agriculture which suits the soil conditions.

Planning the Use of Land

The amount of land in Britain relative to the population is small and there are many claims on it. The following are the main uses to which it is put: food production, forestry, housing, industrial sites, roads and railways, recreation grounds and defence areas required by the Services. For a variety of reasons, the encroachment on agricultural land has increased enormously during the past half century, sometimes with results most unsatisfactory from the national point of view. It is now generally agreed that our dwindling land resources should be carefully husbanded and used to the best advantage. The aims should be:

(*a*) to apportion, as required, for each of the purposes mentioned above, the land best suited to its need with the proviso that, as far as possible, food production should receive special consideration.

(*b*) to utilize the land retained for food production to the best possible advantage by maintaining it at a high standard of productivity, by practising on the various classes of soil the types of agriculture best suited to them and by organising farming units and fixing field boundaries with due regard to soil, type of agriculture, economy of working and social considerations.

In order to achieve these ends, a thorough knowledge of the soils is necessary. The foundation ought to be a detailed soil survey supplemented by additional data bearing on the various purposes for which the land is to be used. At present the information for the country as a whole does not exist, but there is now the nucleus of a soil survey organization and each surveyor can map on an average 40 to 50 square miles per annum on the scale of six inches to the mile.

Some planning authorities contend that land fertility and land classification maps must be constructed at once in order to allow planning on a national scale to be undertaken. However desirable such maps may be, they cannot be produced without collecting the necessary information and generalized maps based largely on opinion are not only of little value but are apt to be misleading and may give rise to the impression that nothing further is required.

For the planning of land utilization, detailed maps and sound scientific data are essential and every effort should be made to secure these with all possible speed. In the meantime, arrangements could be made to have all agricultural land, which it is proposed to divert to other uses, examined first by competent soil surveyors.

FIG. 1.—The Kok-Saghyz Plant.

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Russian Rubber Plants in Britain

F. N. HOWES, D.Sc.

WITH the conquest by the Japanese of those countries in the Eastern Tropics that are the main producers of plantation or Hevea rubber attention was immediately focused on other likely or possible sources of rubber supply.

The total world consumption of crude rubber at the outbreak of war was estimated at about a million-and-a-half tons yearly, three-quarters of this vast quantity being consumed in tyres alone. Malaya produced rather more than half-a-million tons and the Dutch East Indies a similar amount. Other smaller producers of plantation rubber were Indo-China, Burma, Siam, the Philippines, Borneo, India and Ceylon, the two last-mentioned countries producing between them rather more than 100,000 tons or only 1/15th of normal world production. The few Hevea rubber plantations outside the Asiatic plantation zone, notably in tropical Africa, are not extensive and their total production probably under 50,000 tons a year. These figures, combined with the fact that war production means increased rubber consumption, illustrate forcibly the need for developing to the full all other possible sources of supply.

The number of different plants known to contain rubber to a greater or less extent runs into four figures but in very few of these is rubber present in sufficient quantity to make extraction a practical proposition. Although most of the important commercial rubber plants require tropical conditions for growth there are plants that will grow in temperate or sub-temperate climates and which contain rubber in appreciable amounts. It is only in recent years, mainly during the last decade, that such plants have been brought to light and investigated, and this mainly by Russian workers, the Soviet Union having aimed at eventually becoming self-supporting in rubber from home sources. In addition to the production of synthetic rubber, which is considerable, a great deal of attention has been given to discovering and developing alternative sources of natural rubber.

Russian Search for Temperate Rubber Plants

During the period 1931-34 some thirty expeditions were organised in the Soviet Union to search for rubber plants, out-of-the-way parts of Asia and other continents being visited for the purpose. Over a thousand different species were examined. More than half of these contained rubber or rubber-like substances but only a few were regarded as suitable for further experiment or extended cultivation in Russia. Some of these were native plants of the Soviet Union such as "kok-saghyz" (*Taraxacum kok-saghyz*), "krim-saghyz" (*Taraxacum megalorrhison*) and "tau-saghyz" (*Scorzonera tau-saghyz*), while others were plants from foreign countries such as "guayule" (*Parthenium argentatum*—native of Northern Mexico and Texas), and "Eucommia" or the "Chinese gutta-percha tree" (*Eucommia ulmoides*—native of China) certain "milk-weeds" (species of *Asclepias* and *Apocynum*) and golden-rod (species of *Solidago*). The most promising of these has proved to be "kok-saghyz" and this plant has been fairly extensively cultivated for rubber in various parts of Russia, being adaptable to a fairly wide range of climatic and edaphic conditions.

Seed sent to Britain

A limited quantity of seed of some of these plants (notably "kok-saghyz", "krim-saghyz" and "tau-saghyz") has been received from Russia for preliminary or experimental planting in Britain, the first sowing of "kok-saghyz" being made in an experimental plot at the Royal Botanic Gardens, Kew. Arrangements have been made for seed to be sown at some twenty experimental stations in various parts of the country in order to ascertain whether the plants will grow and give a satisfactory yield per acre and whether suitable methods of processing can be devised. Seed of "kok-saghyz" has also been despatched to the United States, Canada, Australia, New Zealand and India, the first consignments to America being carried by air.

The "kok-saghyz" plant, closely allied to the common dandelion which it very much resembles in general appearance and in the nature of the root, was discovered eleven or twelve years ago in the Tian Shan mountains of the Republic of Kazakstan in Central Asia, near the Chinese border. There it was found under bleak inhospitable conditions at altitudes ranging from about 6,500 to 7,500 feet. Incidentally, the name "kok-saghyz" is said to signify "chew root" in the Kazak language, which suggests that gum-chewing was practised and popular in remote parts of Asia long before it became a habit in the United States. The plant proved adaptable to a variety of soil and climatic conditions in European Russia, having been grown experimentally as far north as Archangel. Furthermore it has shown greater resistance to insect pests and diseases than most of the other rubber plants tried. Although occurring in alkaline soils in its natural habitat it has been grown on peat soils (pH as low as 5.5) and has in fact been said to show better growth and higher rubber content in such soils. Under good conditions and with high soil moisture it grows vigorously, once it has passed out of the early seedling stage, and a single plant may produce 50 or more flower heads each yielding numerous small seeds. These are very light and are carried by the wind by means of a parachute mechanism as are those of the common dandelion.

"Kok-saghyz" is grown from seed which is sown in drills about 1½ feet apart, either in the autumn or spring. Propagation is also possible from root cuttings which has the advantage that plants are produced more quickly, weeding is simplified, and risk of admixture with the

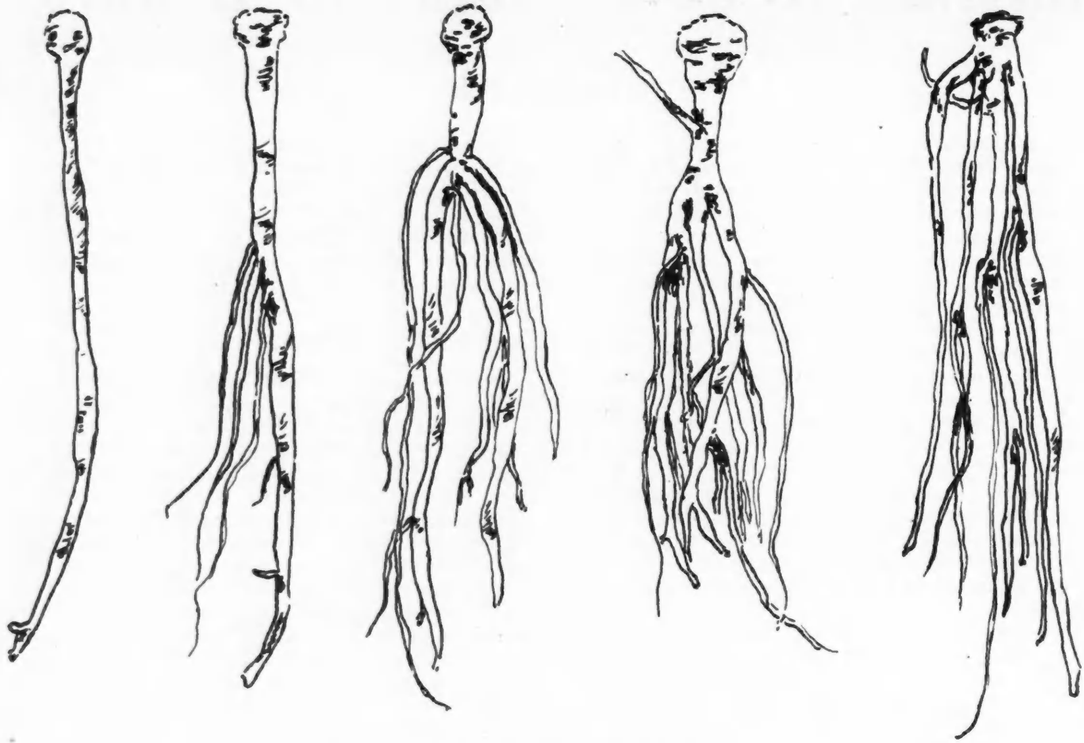

FIG. 2.—Different forms of root in the Kok-Saghyz.

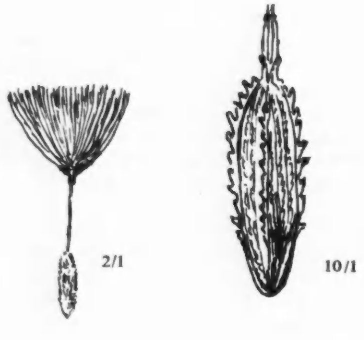

FIG. 3.—Kok-Saghyz seed

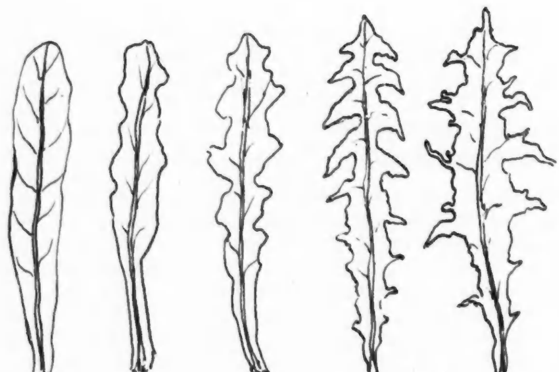

FIG. 4.—Different forms of leaf in the Kok-Saghyz.

ordinary dandelion or other weeds eliminated. On the other hand the use of such cuttings in field planting must require much labour. In the early stages plants raised from seed are somewhat delicate and easily smothered by weeds owing to their slow rate of growth. In Russia it has been found that often a large proportion of autumn-sown plants perish during the winter, but it is possible that in countries where winter cold is less intense autumn sowing may give better results and better developed plants after the first year's growth.

Stratification of the seeds (well moistened and kept at freezing-point) for 25-30 days prior to sowing has been found to be an advantage, stratified seed germinating in 4-5 days after sowing as against 40-50 days for unstratified seed. Shallow sowing, not more than ⅝ inch deep, is also necessary for good germination.

Delayed germination is common with "kok-saghyz". From seed sown at Kew seeds were still germinating after two months while the seeds that germinated early had developed into quite large plants.

Kok-Saghyz Plants at Kew

Laboratory germination tests with Russian seed carried out at Kew this summer averaged over 70 per cent which is very satisfactory for seed of unknown age. Plants from seed sown early in August at Kew in ordinary garden soil (light loam) showed good development two months later, thanks to favourable weather conditions. The plants were of thrifty healthy appearance, the larger ones with rosettes of 10-15 leaves and measuring 6-8 inches, in some cases more, across. How these plants will withstand the damp winter conditions prevailing at Kew and the alternation of frosty weather and mild spells not uncommon in this climate in winter will be watched with great interest. In its natural habitat the plant is protected in the severe winter months by a permanent blanket of snow.

Some of the young "kok-saghyz" plants at Kew show signs of having been eaten back but the cause of this is not clear, whether rabbits, birds or an insect of some kind. However, it is evident that the plant is palatable to wild life of some sort and that it may not be without its enemies in Britain.

The "kok-saghyz" plant fructifies at the end of the first year of growth and the roots may then be harvested for their rubber, but if the plants are allowed to make two or three seasons' growth higher yields of root and a higher percentage of rubber is obtained. The rubber is also of higher quality.

Figures given for yields in different parts of Russia show great variation. This is attributed mainly to the different standards of cultivation that the plants receive but may also be due in part to the very polymorphic nature of the plant and the fact that there has barely been time as yet for stable and selected strains to be evolved. From unselected seed plants of varying habit, leaf and fruiting characters are readily discernible. There are also marked differences in the rubber content and size and shape of the roots of such plants. Up to 1939 there was still no definite variety of "kok-saghyz", the seeds being mixtures of all kinds of wild forms. In the Moscow region up to 5 tons of roots per hectare have been lifted from good soils, one yield of 5½ tons producing 234 kgms. of rubber. This represents approximately 4¼ per cent of rubber in the roots, although considerably higher percentages have been recorded.

Compared with Hevea rubber where yields of 800-1000 lbs. of rubber per acre are not uncommon, the yield to be expected from "kok-saghyz" is very low. Furthermore, the labour demands in weeding, cultivation and harvesting are heavy. The one great advantage the plant possesses in the light of present conditions is that rubber may be obtained from it after one season.

In harvesting, roots are dug with a modified sugar-beet lifter, cleaned, the tops removed and then dried or partially dried if required for immediate processing. This consists essentially in grinding the dried roots to powder, macerating with water or with alkaline solution and separating the rubber from the other matter by gravity or centrifuging. In Russia the use of sugar beet installations, otherwise idle for part of the year, has been considered for effecting part of the processing. The same might apply in Britain and the United States. What are considered likely areas for the plant in the United States, coincide in fact with the present sugar beet areas and seed has been distributed to these areas. As autumn harvesting of the two crops would overlap somewhat and make heavy demands on labour it is thought that the two year plantation with harvesting during June and July might eventually prove the most satisfactory.

Rubber and the British Dandelion

The value of "kok-saghyz" or "Russian dandelion" as a rubber producer naturally raises the question as to what extent, if any, is rubber present in the common British dandelion (*Taraxacum officinale*), one of the commonest plants in all parts of the country. Roots recently collected at Kew and examined for rubber gave only 0·25 per cent of rubber dry weight (direct acetone and benzene extraction) the rubber being "reasonably elastic but a little tacky" and giving "a moderately good vulcanisate". From this it would seem that the percentage of rubber is far too low for practical considerations but further investigations are in progress with different varieties or species of British dandelion.

American Milkweed

Another plant in cultivation at Kew and recently tested for rubber, thanks to the Rubber Research Committee, is the American milkweed, *Asclepias syriaca*. This plant grows readily in Britain producing large leafy stalks 4-6 feet in height each season and would be well adapted for field cultivation. Unfortunately, the rubber yield proved to be only 0·44 per cent dry weight and the rubber of poor quality. Much higher yields, up to 4 per cent, have been recorded from the leaves of this plant in its natural habitat, North America. Possibly the mild humid climate of Britain with a relatively cool summer does not favour rubber production in this particular plant.

Other wild or cultivated plants in Britain known to contain rubber, but only in very small quantity are the sow-thistle (*Sonchus oleraceus*), spurges (*Euphorbia* spp.), wild lettuce (*Lactuca* spp.), *Euonymus*, *Campanula* and Golden rod (*Solidago* spp.).

Eucommia

Of the other Russian rubber plants already referred to *Eucommia ulmoides* the "Chinese gutta-percha tree" has been in cultivation at Kew as an ornamental tree for about 40 years and several good specimen trees now exist in the grounds. The gutta content of the leaves is about 3 per cent and that of the bark rather higher. It has not been developed as a commercial rubber producer in the past owing to its inability to compete with Hevea rubber. In Russia, plantations are propagated by cuttings or rooted branches and come into bearing in 4-5 years, the leaves only being used.

Tau-Saghyz

"Tau-saghyz" (*Scorzonera tau-saghyz*) is, like "kok-saghyz", a native of Central Asia, being wild in the Kara-Tau mountains near Tashkent. It was discovered in 1929 and was one of the first wild plants studied in Russia as a likely source of rubber. It occurs at altitudes from 3250-5850 feet with a temperature ranging from $-35°$C. to $+40°$C. In its natural habitat it receives a good deal of sunshine and strong dry winds with a frost period lasting for about 8 months of the year. Rubber occurs throughout the plant but is located mainly in the root bark. Seedling plants develop slowly and require about three years before they are really large enough for rubber extraction. A tendency for the roots to rot has proved a distinct drawback, and has in fact proved the chief obstacle to cultivation. Although very much to the fore in Russia a few years ago as a rubber plant it appears now to have been eclipsed in large measure by "kok-saghyz".

Krim-Saghyz

"Krim-saghyz" (*Taraxacum megalorrhizon*) is closely related to "kok-saghyz" and, as the name implies, is a native of the Crimean Peninsula, where it enjoys a comparatively mild climate with only brief winter frosts and lives for several years. It is much less resistant to cold than "kok-saghyz" and in most parts of Russia will not survive the winter. For this reason it has now been largely supplanted by "kok-saghyz". The plant is said to have grown well in Sicily.

The rubber is present in the roots and is of good quality. Year-old plants are said to contain only 1-2 per cent, but two-year-old plants give a considerably greater yield—6-7 per cent dry weight. The rubber exists in the roots in the form of threads and may be extracted as in the case of "kok-saghyz".

Seeds of both "krim-saghyz" and "tau-saghyz" have been distributed for trial in Britain in the same way as that of "kok-saghyz" but it is thought they are less likely to thrive and prove promising.

Guayule Rubber

Among the plants not native to Russia that have attracted attention as rubber producers in the Soviet Union in recent years "Guayule" (*Parthenium argentatum*) takes first place. This shrub, as already stated, occurs wild in the northern part of the Central Plateau of Mexico and extends into Texas. It has long been known as a rubber plant and wild plants were exploited for rubber in Mexico long before the Hevea plantation industry of the East was developed. A good deal of attention has also been given to the cultivation of the shrub in the southern United States and much valuable experimental work carried out, particularly in regard to the development of high-yielding strains, and to large scale mechanized cultivation and improved methods of processing.

In areas where the "guayule" shrub occurs conditions are hot and dry with an average annual rainfall of only 7-14 inches. Although the plant will withstand fairly low temperatures it is unsuited to a moist or humid climate and for this reason is not considered at all likely to thrive in Britain. There are, however, many parts of the British Empire where cultivation might be expected to succeed.

In Russia it has been found that the plant can be cultivated in certain arid and sub-tropical regions, in semi-desert zones and in the steppes, where conditions are unsuited for other rubber plants. Plants of two selected strains have been found to contain from 6-7 per cent rubber at two years old, giving yields of 100-175 kilos per hectare (89-156 lbs. per acre). Research has been aimed at the production of larger-sized plants and higher rubber content at an early age.

In the United States the question has been raised whether by growing young plants close together and harvesting them in one year the greater number of plants would compensate for the smaller amount of rubber in each one. It is stated that in California plants less than one year old have been found to contain 6 per cent of rubber. This plan of sowing thickly and harvesting after one year does not appear to have been yet carried out on a large scale but is obviously of particular interest at the present time.

Development in Radio-Communication

In the House of Commons the Minister of Production, Mr. Oliver Lyttelton, has stated in an answer that in view of the great increase in the importance of wireless communication and radiolocation during the war, it was considered necessary to strengthen the existing organisation for controlling research development and production in that field. The Government had therefore set up a Radio Board as the co-ordinating body in regard to inter-service policy, research, development and production. The Minister Resident for Supply in Washington acted in his personal capacity as the first chairman of the Board. On his appointment to Washington he had been succeeded by the Minister of Aircraft Production, also in his personal capacity. The chairman was assisted by two deputy-chairmen, the Parliamentary Secretary to the Ministry of Production and Professor G. P. Thomson. Membership of the Board included representatives of the Admiralty, War Office, Air Ministry, Ministry of Supply, Ministry of Aircraft Production, and General Post Office, as well as several special (non-departmental) members.

Far and Near

"EARLY in the war," says Lord Hankey, "Mr. Chamberlain asked me to try and help science on the war map." Certainly that has been accomplished, and it is very interesting to trace the part that this non-scientist has played in accomplishing the organization of scientific man-power.

Having become Chairman of the Scientific and Engineering Advisory Committees, as well as the Wireless Personnel Committee, as such he was approached in September 1940 by Air Chief Marshal Sir Philip Joubert with a personnel problem for manning wireless and radiolocation units.

Consultation with the Minister of Labour and National Service gave Lord Hankey the use of the Central (Technical and Scientific) Register. Through the Register and by other means, the first canalization of scientists into the wider war effort was achieved.

The number was not sufficient however to meet the nation's needs. More and more scientists were and still are needed. Lord Hankey was then handed by Mr. Ernest Bevin the task of organizing the training of young scientists.

"Once more," comments Lord Hankey, "the willing aid of universities and technical colleges was enlisted to train mechanical and electrical engineers and chemists, many of whom were awarded bursaries."

In March last, Mr. Bevin set up a new Appointments Department, of which the Central Register forms a part. Lord Hankey envisages the growing up of an "Imperial Department under the Minister of Labour and National Service linked with the Dominions and India for the purposes of interchange and furnishing scientists and engineers for home research, industry, the Fighting Services, Colonies and foreign countries when required."

Of this scheme the Central Register is the key, and Sir Lawrence Bragg voices the opinion of many scientists when he says that "one would like to see a permanent body with the same functions set up after the war."

THERE are now some forty reports by different bodies upon post-war education. A distinguished committee has made an interim report on Post-War University Education to the Council of the British Association for the Advancement of Science.

In the sections dealing with science the committee have been impressed by the tendency in university studies to specialize at the expense of a broader field of work. It welcomes the proposal that there should be a general degree course including both natural science and humanities. It also discusses a proposal for the inclusion in the existing specialised schools in natural science and applied science courses in the elements of sociology and citizenship.

The ultimate aim of post-war university education would be, as Professor Whytehead has aptly said, "to construct a system of ideas which bring the aesthetic, moral and religious interests into relation with those concepts of the world which have their origin in natural science."

THE practice of the Ministry of Aircraft Production in preparing and circulating summaries of articles appearing in the technical press of the world is a sound piece of work. Some of the larger industrial firms receiving these releases are, we learn, making valuable use of them by incorporating them and other work by their own research staff into house publications.

The circulating of abstracts is valuable in more ways than one. Inside works it opens up horizons for staff and technicians, and for the busy scientist and research worker it enables him to avoid working along lines already explored.

It is a fact, we believe, that in recent months the re-reading of work already done in certain fields aided the development recently made in the liquid-cooled engine. The implications of this happy "literary research" work in old abstracts leads one engineering journal to suggest that a central index might usefully be established, to which workers in various branches of science could have easy access.

THE E.R.A. technical report on *Simplified Electrically Heated Hotbeds* describes experiments carried out to determine whether a simple method of heating hotbeds electrically can be applied successfully to the intensive production of early salad crops in small frames such as are used by amateurs. The method consists essentially in equipping a frame with a soil-heating cable or with a transformer-fed bare iron wire to give a loading of from 2 to 5 watts per square foot. Heating is controlled, from a convenient point in the domestic premises from which supply is taken, to give certain regular "doses" of heat in each 24-hour period. These doses vary from 40 to 45 watt-hours per square foot per day, depending on the district. The two most convenient modes of procedure appear to be either with a loading suitable for all-night running or with a lower loading suitable for continuous running. The method is designed for operation on the domestic two-part tariff and to take advantage of the low running charges available.

The experiments have shown that the method is a practical and economical way of producing lettuces of first-class quality from mid-March onwards, with little attention and at a total cost, including overhead charges, well below the current retail prices in shops. While early lettuce is the main crop, other crops can be raised, either simultaneously, such as carrots, or in succession, thus adding to the value obtainable from the hotbed installation.

MR. G. A. SEEVEN, naturalist on the scientific staff of the Marine Biological Association, has been recalled from service in the R.N.V.R. to take a temporary appointment as Fishery Development Officer, Sierra Leone.

Since the war began Sierra Leone, with other West African colonies, has suffered from a shortage of fish supplies, for the salted stockfish from Norway, formerly taken in large quantities, can no longer be imported. It is hoped that with suitable organization the deficiency can be met, at least in part, by the expansion and development of the local sea fisheries. In West Africa it is evident that

fish are plentiful and the potential fishing grounds cover a large area.

In most of our colonies very little attention has hitherto been given to the subject of fisheries and of even the most important and abundant species of fish our knowledge is negligible. Scientific investigation of colonial fishery resources is overdue and it is hoped that it will be given consideration in any plans for post-war colonial development.

A Joint Council of Professional Scientists, representing over 10,000 qualified scientists, has been set up under the chairmanship of Sir Robert Pickard, F.R.S., by the Institutes of Chemistry and Physics, in association with representatives of professional botanists, geologists, mathematicians, and zoologists. The Council has been established to voice the collective opinion of qualified scientists on matters of public interest, to provide a liaison between professional organizations of scientists for co-ordinated action in matters of common interest, and in particular to concern itself with:

(i) the utilization of scientists to the best advantage in the service of the community;
(ii) the education, training, supply and employment of scientists;
(iii) the better understanding of the place of scientists in the community;
(iv) the maintenance of adequate qualifications and ethical standards among professional scientists;
(v) the supply of information and advice to public and other bodies on matters affecting scientists.

The Members of the Council are as follows:

Representing the Institute of Chemistry:

Dr. J. J. Fox, C.B., O.B.E., F.I.C. (President, Institute of Chemistry)
Prof. Alexander Findlay, F.I.C.
Dr. G. Roche Lynch, O.B.E., F.I.C.
Sir Robert Pickard, Kt., F.I.C., F.R.S.
Dr. H. A. Tempany, C.M.G., C.B.E., F.I.C.
Mr. R. B. Pilcher, O.B.E. (Registrar and Secretary, Institute of Chemistry)

Representing the Institute of Physics:

Prof. Sir Lawrence Bragg, Kt., O.B.E., F.Inst.P., F.R.S. (President, Institute of Physics)
Prof. J. A. Crowther, F.Inst.P.
Mr. E. R. Davies, F.Inst.P.
Dr. B. A. Keen, F.Inst.P., F.R.S.
Dr. H. Lowery, F.Inst.P.
Dr. H. R. Lang, F.Inst.P. (Secretary, Institute of Physics)

Representing Botanists: Prof. W. Brown, F.R.S.
Representing Zoologists: Prof. D. Keilin, F.R.S.
Representing Mathematicians: Prof. S. Chapman, F.R.S.
Representing Geologists: Prof. H. H. Read, F.R.S.

The Joint Council has been established for the period of the National Emergency, but it may form the nucleus of some more permanent organization to facilitate the close collaboration between professional men and women practising in all branches of science.

The Association of Scientific Workers is to hold a Conference on the Planning of Science in London on 23 and 24 January. The three sessions which are envisaged will cover not only national planning but the essential part which initiative from below must play in the carrying out of any great co-operative enterprise. A final session will look farther ahead and will attempt to assess how far the changes forced upon science by the war should be incorporated as permanent features of British science.

It is encouraging to watch the progress that scientists in the U.S.S.R. are making under the enormous difficulties in which they work.

In addition to their war work, the anthropologists of Moscow University have been carrying on research of a purely theoretical nature. For the first time investigation is being made of the Yenisei Taiga, the most western region of the Taiga in Siberia. The problems now being studied are of importance in establishing the kinship between the indigenous population of Siberia and the aboriginal tribes of North America.

Professor Vernyatsky, who holds the chair of anthropology at the Moscow University, is making a study of the skeleton of a neanderthal child unearthed in Uzbekistan.

This summer scientific workers of the anthropological faculty conducted a series of investigations of the physical development of the Turkmenians, the formerly nomadic people living to the east of the Caspian Sea, near the borders of Iran and Afghanistan. One of the problems investigated was the artificial deformation of the skull, resulting from the ancient Turkmenian custom of binding the heads of children at an early age.

The Leningrad Botanical Institute, the largest in the U.S.S.R., has not suspended its work despite the siege. The institute has an extremely rich botanical collection of some seven million plants. Its library contains 135,000 volumes on botany. Over 20,000 specimens of plants from all parts of the world are to be found in its gardens, which were laid out about 230 years ago on the order of Peter the Great. The hothouses alone occupy over 35,000 square yards.

While the Germans were shelling the city Professor Rozhevich completed his monograph entitled *The Biology and Economic Importance of the World's Cereal Plants.* A number of other scientists also completed researches, some of which were directly related to the needs of the Leningrad front.

The Editor will be pleased to receive contributions to Discovery, which will be carefully considered and paid for if accepted. He will also always be glad to consider suggestions for articles.

If any reader experiences difficulty in obtaining copies of this magazine, please communicate with the publishers at The Empire Press, Norwich.

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